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FOUNDED BY C. E. LINEBARGER

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CONTENTS:

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SCHOOL SCIENCE AND MATHEMATICS

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JANUARY 17, 1706

Birthday of Benjamin Franklin

America's first Scientist—A statesman of first rank—A great educator—Author and journalist—Philosopher—Inventor—Diplomat—Business man—Public official—Athlete—Soldier.

What Franklin Did

Proved the identity of lightning and electricity.

Formulated a theory of what electricity is.

Founded the University of Pennsylvania.

Founded the first circulating library in America.

Invented a stove.

Invented the lightning rod.

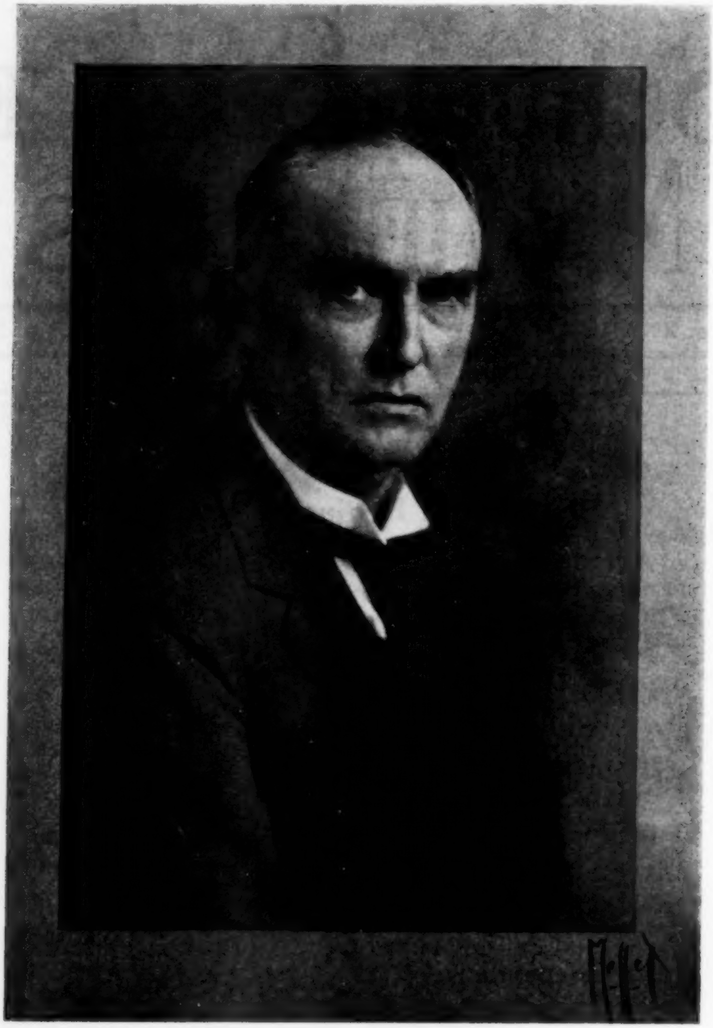
Corrected Jefferson's first draft of the Declaration of Independence.

As Postmaster-general for America, he operated the American postoffice at a profit.

Persuaded France to assist the United States.

Wrote *Poor Richard's Almanac, Autobiography,* and a long list of essays and letters on political questions, religion, electricity, medicine and health.

No other man excelled in so many fields. Why not make the January science club meeting a Franklin celebration?



GEORGE WILLIAM MYERS.

The name of George W. Myers appears as Associate Editor of Astronomy, in the first issue of SCHOOL SCIENCE AND MATHEMATICS. He also contributed to that issue an article on *High School Astronomy*. For thirty-one years he was an active member of our editorial staff, contributing the interesting article *Great Turning Points in Astronomy's Highway* to the October, 1931, issue. In the time between these two articles he gave us a list of more than thirty

contributions on the teaching of astronomy and mathematics in addition to his editorial work.

Dr. Myers left us November 23 and his body was laid to rest near the place of his birth at Urbana, Illinois. Although his work is ended his influence lives. He was a great teacher and hundreds of his pupils now occupy positions of trust and influence in many professions and industries. He was especially apt at originating teaching devices to assist in instruction. Teachers of astronomy, mathematics, and general science will find his articles in this journal a very useful suggestion box. In the study of educational principles he has been characterized as being a quarter of a century in advance of his time. No other movement in the teaching of secondary mathematics has so stimulated research in this field as has correlated or unified mathematics. Dr. Myers was the real pioneer in this field as is shown by his two books *First Year Mathematics* and *Second Year Mathematics* for secondary schools which appeared in 1910. Since then this movement has been promoted by others in all sections of the country and similar texts are in use everywhere. His last major work in the textbook field was as editor of the *Standard Service Arithmetics*, and a number of auxiliary teaching devices in secondary mathematics such as algebra and geometry work books, flash cards and tests.

Dr. Myers received the bachelor's degree from the University of Illinois in 1888, and the master's degree in 1891. He then became an instructor at that institution and continued his studies in the school of engineering. He next spent a year abroad and received the Ph. D. from the University of Munich in 1896. Returning from Europe he was made Associate Professor of Astronomy and Applied Mathematics at the University of Illinois. While in this position he planned the observatory there and selected and installed its telescope. In 1900 he became head of the mathematics department of Chicago Institute. The following year he was appointed Professor of the Teaching of Mathematics and Astronomy at the University of Chicago and held this position for nearly thirty years, retiring in 1929.

MULTUM IN PARVO.

By Evan Thomas,

The University of Vermont, Burlington, Vt.

Readers of the once popular romance, Peter Schlemihl, will remember that the gentleman to whom Peter had a letter of introduction was, at the time of his visit, entertaining a select company of friends on his beautiful and spacious grounds. In the company, but evidently not of it, was a tall, thin, elderly man, about whose appearance there was an indescribable air of mystery. From the breast pocket of a tight fitting grey coat he pulled out for the comfort or entertainment of the company, as occasion arose, a piece of English plaster, a telescope, a Turkish rug, a tent with full equipment, and last of all three saddled horses. Strangely enough no one seemed to see anything more unusual about the proceeding than if he had pulled out a pocket handkerchief or a pair of gloves.

Every reader of high school physics is familiar with the formula $s=16t^2$. This is coldly realistic when placed beside the romantic pocket, but in simplicity of form and wealth of content they are close rivals. In both we have a veritable *multum in parvo.* The picturesqueness laid one side, the advantage is plainly on the side of the formula, which contains an astonishing assortment of mathematical notions of the greatest interest and practical value, and are easily accessible even to those of limited mathematical talent or training. It is the purpose of the following paragraphs to direct attention to some of these notions, without any attempt at extended exposition.

The Linguistic Aspect of Mathematics.

Mathematics provides a language which is in essential purpose quite comparable with the vernacular. In both the object is to express and convey thought. This aspect of mathematics appears to good advantage in the formula. In it we have a most compact and perspicuous statement of the relation between the distance and the time in the case of a falling body. Its merit as compared with the vernacular becomes evident at once if we translate the formula into words. Another advantage is that by simple manipulation we can reach conclusions difficult or impossible by the use of verbal language. For example, if we want to know how long it will take a body to fall a given distance an easy transformation provides the desired information. $t=\frac{1}{4}\sqrt{s}$. The superiority of mathematical language as an organ of ex-

pression for the quantitative aspects of physical science becomes still more impressive if one is prepared to read Clerk Maxwell's translations into differential equations of the results of Faraday's experimental work. The device of substituting symbols for words and equations for sentences must be accounted one of the sublimest achievements of the human mind, and this linguistic aspect should not be overshadowed, as it often is, by the thought of mathematics as an art of computation or a method of juggling with symbols.

Continuous Variation.

From the nature of the phenomenon it is obvious that s and t are essentially variable quantities. It is also clear that the variation is continuous in the sense that both s and t pass from one value to another by passing through every intermediate value. This is a very different mode of quantitative variation from that in which the changes take place abruptly or by jumps like the fluctuations of the stock market, or the height of a brick wall under construction. The variation here is more like the growth of a tree, the flow of heat or an electric current. It is true that we speak of the passage of time in terms of days, hours, minutes or seconds, but this is artificial and wholly a matter of convenience. Time does not increase by the addition of intervals but by a continuous flow. The same is true of the increase of distance. In this mode of variation the term interval, however short, has no place except as an aid to conception. It is often said that in this and similar cases time and distance increase by infinitesimal increments, but this introduces into the phenomenon difficulties not inherent in it. Magnitudes in a state of continuous variation form the subject-matter of a large part of mathematics. The line which divides this from the constant quantities considered in arithmetic and algebra may also be said, roughly, to divide elementary mathematics from the so-called higher mathematics.

The Function Concept.

The quantities s and t, though themselves variable, are bound together by an invariable relation expressed by the equation. Any change in one is always accompanied by a definite and calculable change in the other. The variable to which a value is assigned at pleasure is, for practical convenience, called the independent variable, while that whose corresponding value is calculated is called the dependent variable or function. If we

make $t=3$ sec., $s=144$ ft., the distance through which the body falls from rest in 3 seconds. If we want to know how long it will take the body to fall 100 ft., $t=\frac{1}{4}\sqrt{s}=\frac{1}{4}\sqrt{100}=2\frac{1}{2}$ sec. This idea of mutual dependence is basic in mathematics and enters into every phase of human thought. It may happen that all we care or which the data will enable us to affirm is the fact of mutual dependence, in which case it will suffice to write $y=f(x)$, if x and y are the variables, a form of expression the study of which is too long postponed in American schools.

Instantaneousness.

This idea is closely related to that of continuous variation, and plays an important role in mathematics. Corresponding to every instant there is a definite and calculable position of the body, a position occupied at no other instant. This position can be determined by direct substitution in the formula. At the end of 3 sec., for example, $s=16(3)^2=144$ ft. The body has also an instantaneous velocity; i. e., a definite and calculable velocity corresponding to every instant of time and to every point of the path. This, however, cannot be calculated by direct substitution in the formula. But the necessary formula is implicit in the primitive and can be worked out by anyone possessing a little knowledge of elementary algebra.

There are different methods of getting the derived formula out of the primitive. The method most approved at present makes use of a collapsible framework of deltas which as the collapsing progresses tends towards the form of the desired formula. To set up this framework we start with the original formula,

$$(1) \qquad s=16t^2$$

Since t is increasing let the new value be $t+\Delta t$, in which Δt (Δt is not a product but a single symbol and is read "*delta t*") is any addition to the time. In consequence of this addition to t it is obvious that s will take on a corresponding increase, which we appropriately denote by Δs ("*delta s*").

The equation connecting distance and time now becomes

$$(2) \qquad s+\Delta s=16(t+\Delta t)^2$$

Expanding and subtracting (1) from (2),

$$(3) \qquad \Delta s=32t\Delta t+16\Delta t^2$$

Dividing by Δt,

$$(4) \qquad \frac{\Delta s}{\Delta t}=32t+16\Delta t.$$

At this point the physical significance of (3) and (4) should be carefully noted. In (3) Δs is the calculated addition to s corresponding to Δt, the assigned addition to t. If we assume an increase of 2 sec. immediately following third second we have $\Delta s = 32(3)(2) + 16(2)^2 = 256$ ft. In (4) we have an expression for the average velocity during the 2 sec. immediately following the first 3 sec. of fall. Numerically,

$$\frac{\Delta s}{\Delta t} = 32(3) + 16(2) = 128 \text{ ft./sec.}$$

But this is not the information we are seeking. What we want to know is the exact velocity at the end of 3 sec. or the state of the body with respect to motion at that instant, often called the instantaneous velocity. This distinction between average velocity and instantaneous velocity should be firmly grasped. A closer examination of (4) will lead to the desired information.

The key to the present situation is found in the fact that Δs and Δt enter into the operation as magnitudes in a state of simultaneous decrease, each on its way towards zero. Applying this idea to (4) and fixing attention upon the second member we get at once a glimpse of what we are after, namely, $32t$, which is the instantaneous velocity at the end of t seconds. For, obviously, if Δt approaches zero the term $16\Delta t$ also approaches zero, and the whole of the second member approaches $32t$, which, as a matter of fact, is the actual velocity at the chosen instant. We have now passed from an expression for an average rate to an expression for an instantaneous rate. For this particular value of the ratio it is customary to substitute $\frac{ds}{dt}$ for $\frac{\Delta s}{\Delta t}$. Symbolically,

$$(5) \qquad \frac{ds}{dt} = 32t$$

By the use of (5) we can calculate the instantaneous velocity by direct substitution. If we want to know the velocity at the end of 4 sec. we have

$$\frac{ds}{dt} = 32(4) = 128 \text{ ft./sec.}$$

In (4) the quantities are so bound together that whatever happens to the second member the effects are felt in the first member. How to interpret these effects is a question which troubled mathematicians for two centuries, and even today there are differences of opinion on the subject. Since Δt is made zero in the second member the same thing must happen in the

first member, and since Δt and Δs decrease simultaneously and reach zero together the first member is reduced to the apparently meaningless form $\frac{0}{0}$. This, however, does not destroy the significance of the second member, and it is, rather obviously, permissible to replace the obscure $\frac{0}{0}$ by any two numbers having the ratio $32t$. Here we have chosen for such numbers dt and ds. This is not the place to discuss the logic of the operation, but two illustrations, one algebraic and the other physical, may help to show that the expression $\frac{0}{0}$ is not so meaningless as it seems at first sight.

The reader is familiar with the fraction $\frac{a^2-b^2}{a-b}$, which by the simple operation of division may be written

$$\frac{a^2-b^2}{a-b}=a+b.$$

Now if b is made to approach a in value the remainders $a-b$ and a^2-b^2 approach zero in value, and we have a result quite analogous to $\frac{0}{0}=32t$, namely, $\frac{0}{0}=2a$.

Bashforth's method of measuring the muzzle velocity of a rifle is elucidating. He placed a screen electrically connected with a clock at a carefully measured distance from the gun. He then divided the distance Δs by the time Δt. The quotient gave the average velocity of the bullet during the interval Δt. He then reduced the distance and the time and again calculated the average velocity, which was now greater, though the elements of the fraction were less. The nearer the screen was brought to the muzzle of the gun the smaller the elements of the fraction but the greater the ratio, which at least suggested the inference that when the distance became very near zero the quotient very nearly represented the actual velocity of the bullet as it left the barrel of the gun.

Basic Ideas in Higher Mathematics

A further examination of (4) and (5) will lead to several ideas basic in higher mathematics.

a. *Difference and differential.* In Δs, Δt we have a difference in the ordinary arithmetical sense. The only unfamiliar aspect is the notation. Δt and dt are alike in that each represents a difference between two values of the variable t. They are unlike in that Δt is thought of as a variable approaching zero as a limit, while dt is a constant in the present connection. Δt is known as an increment, dt as a differential. The difference between the

increment Δs and the differential ds is more pronounced. In Δs we have the numerator of the fraction which represents the average velocity during the interval Δt; in ds we have the numerator of the fraction which represents the velocity at a given instant, or at the initial point of Δt. We may say that Δs is the actual performance of the body during the interval of time Δt. On the other hand, to use a suggestion of De Morgan, if we endow ds with volitional power, we may say that ds represents the intention of the body at the beginning of this interval, an intention not carried out because of the continued operation of gravity during the interval. This distinction may become clearer by numerical substitution in (3) and (5) written in the form $ds = 32tdt$.

b. *Differential coefficient.* The factor $32t$ by which the differential of the independent variable is multiplied to produce the corresponding differential of the function, is called the differential coefficient of the function. This factor is, in general, as in the present case, variable. Consequently ds is variable while in simpler problems dt is constant. The calculation of this factor for various functions is the fundamental problem of the differential calculus, and the reader who has followed closely the preceding steps has caught at least a glimpse of the characteristic aspects and processes of that great branch of mathematics.

c. *Limiting values.* This is a concept of the highest importance in mathematics. The student of elementary algebra has a glimpse of it in the derivation of the formula $s = \frac{a}{1-r}$ in geometrical progression, for example. We have used it in passing from $32t + 16\Delta t$ to $32t$, and from $\frac{\Delta s}{\Delta t}$ to $\frac{ds}{dt}$. The logic involved in the transition requires greater preparation than is here assumed. Happily in practical work we are not required to make direct use of the idea, for the rules for the calculation of the differential coefficient have been formulated and are easily available to the student ambitious to proceed to the study of rates of change.

A Pedagogical Interest

The primary interest of the preceding paragraphs is, of course, pedagogical rather than mathematical. They cover a range of mathematical notions easily within the reach of teachers of mathematics in secondary schools, even those who may not

have taken the usual undergraduate course in the subject. A panoramic view of important mathematical territory cannot fail to be enriching and profitable to a teacher who may be so situated that he cannot hope to make extended explorations and minute surveys. The basal ideas of mathematics are simple and easily accessible to those who do not aspire to become professional mathematicians. The remote deductions, where difficulties are encountered, as Whitehead observes, are not of primary theoretical interest. It goes without saying that a teacher should have complete mastery of the portion of the subject covered by the classwork. "This mastery of the subject matter is attained in part by intensive study of the subject taught, in part by extensive study of a wide range of mathematical subjects. In fact, the latter variety of study prepares the way for the former. Teachers may be tempted to confine their personal reading to phases of what they are teaching. A certain amount of such work is very good, but when carried too far without the illumination of much broader mathematical acquisitions, it is apt to be sterile" (J. W. A. Young).

CALENDAR REFORM.

The University Association for the Study of Calendar Reform has a membership in more than 75 Universities and Colleges, practically all the leading schools of America being represented. As should be the case, all opinions on the matter of calendar reform are included. This summer, questionnaires have been conducted among certain groups to see whether opinion on the whole favored revision, and also to obtain opinions and comments on the relative merits of the more favored 12-month revisions and the 13-month plan. The results are summarized in the following table:

	Astronomy	Banks	Education	Transportation
Replying	134	586	400	197
Favoring revision	67%	47%	90%	61%
Opposing revision	28%	48%	8%	36%
Favoring 13 months	25%	19%	31%	17%
Favoring 12 months	62%	55%	61%	63%

It will be seen that bankers are the most conservative and educators the least so of the groups canvassed, but on the whole a good majority favors some revision of the calendar. It is also apparent that the twelve months must be retained if a plan for revision is to win favor at this time. The ablest minds are, however, not agreed. One can advocate no alteration of the calendar, a 12-month revision, or the 13-month plan, and still be in agreement with the famous men. This shows that there should be further study of fundamental facts, and in this investigation colleges, universities, and research institutions can appropriately take a leading part.

A STUDY OF THE ACHIEVEMENTS OF STUDENTS OF GENERAL CHEMISTRY IN COLLEGE.[1]

BY WILLIS J. BRAY,

Northeast Missouri State Teachers College, Kirksville, Mo.

Much has been written concerning the achievement of students of general chemistry in college, but very little has been done to discover the factors which might condition success in the study of this subject. It is the purpose of this study to consider certain factors which may have some bearing on the success of students of general chemistry at the college level.

In beginning this study, the cooperation of five colleges located in different sections of Missouri was secured. These five colleges had a total general chemistry enrollment of about 320 in the beginning of school year 1929-1930, when this study was begun. A careful study of the students included in this group showed them to be typical students of beginning general chemistry with an average age of 19¼ years. At the beginning of the quarter the first form of the Iowa Chemistry Training Test, Revised, was administered to the group in order to measure the achievement level of each student in this field before he had studied the subject in college. At the end of the quarter the second form of this same test was administered in order to measure the achievement of the same group at the end of the quarter of instruction in the subject. Table I gives a summary of the results obtained from these tests.

TABLE I—SUMMARY OF RESULTS BASED ON IOWA CHEMISTRY TRAINING TEST.

	Form A	Form B
Number of cases	323	311
Range of scores	140	150
Mean score	33.97	63.10
Median Score	28.56	56.75
Standard Deviation	22.65	26.97
Q_1	18.94	43.23
Q_3	44.64	80.56
Q	12.85	18.66
Standard Error of Avge.	1.26	1.53
Coef. of variability	66.67	42.74

[1]This paper is abstracted from a dissertation presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the University of Missouri, 1931, and published as a bulletin (Vol. XXXI, No. 6) of the Northeast Missouri State Teachers College.

A study of Table I shows that, on the first form of this test, at the beginning of the term, the mean score was only 18 per cent of the possible score. The student at the 75 percentile point scored 2.36 times as high as the one at the 25 percentile point. The poorest student scored only 1 on this form of the test, while the best student in the group scored 141.

One of the most striking facts shown in Table I is the extremely high value of the coefficient of variability on both forms of the test, but particularly on Form A (66.67). This may possibly be due in part to the fact that 23 per cent of the group had studied high school chemistry, 32.9 per cent of the group had studied high school physics, 17.7 per cent had studied high school biology, while 50.9 per cent had studied general science in high school. Others had studied various combinations of these sciences, while a small percentage of the group had never studied any science before. In any case the data would seem to indicate that there is a serious problem for the teacher of general chemistry who can not section his class on the basis of ability to achieve in this subject, unless he would adopt an attitude of indifference toward the individual student and his problems.

The results of the second form of this test show that the achievement level of the group, as indicated by the mean scores on this test, had greatly increased, while most of the measures of dispersion had decreased. The coefficient of variability decreased from 66.67 to 42.74. At the beginning of the term about 68 per cent of the group would most probably score between 11.3 and 56.6 on this test, while at the end of the term, about 68 per cent would most probably score between 36.1 and 90.1. The coefficient of variability at the beginning of the term was about 1.56 times as great as at the end of the term. At the end of the term the range of scores was from 10 to 163.

The norms of this test are based on either a year of high school chemistry or one semester of college chemistry. Less than one-fourth of this group had studied chemistry in high school, and none of them had studied the subject more than 12 weeks in college. The mean, as well as the standard deviation of the group, is slightly lower than the norm.

The 75 percentile point of the present group is considerably lower than the norm, while the 25 percentile point is practically the same as the norm for the test.

TEACHERS' MARKS.

No effort was made to prescribe any uniform method by which each of the teachers cooperating in this study should determine the final mark of each student. For convenience in statistical treatment marks for each student not reported in percentages were translated accordingly from the letter grades given. In the two institutions which used the semester basis the instructors gave the tests as scheduled and determined the standing of each student as of the date of closing of the quarter, just as if they had been on the quarter basis. Thus the marks were made comparable. Table II gives a summary of the data obtained from a study of the distribution of teachers' marks.

TABLE II—SUMMARY OF RESULTS BASED ON TEACHERS' MARKS.

Number of cases	314
Range of scores	64
Mean	78.29
Median	80.58
Standard deviation	11.29
Q_1	73.29
Q_3	86.48
Q	6.50
Standard error of avge.	.64
Coefficient of variab.	14.42

A study of Table II shows that the mean teachers' mark of this group was 78.29 per cent. About 50 per cent of the group would most probably score between 74 and 87 per cent. The results in this table indicate that the best student of the group has an achievement level in chemistry about 2.82 times as high as the poorest.

INTELLIGENCE QUOTIENTS.

At the beginning of the term the Otis Self-Administering Test of Mental Ability, Higher Examination, Form C, was administered to the group. The results of this test show that the average student in the group has an intelligence quotient of 105.94. The standard deviation is 10.33, and the range of intelligence quotients from 79 to 131. The student with the lowest intelligence quotient would certainly be more or less seriously handicapped in keeping

pace with students in the higher group in intelligence. The best student in the group ranks 1.66 times as high in intelligence quotient as the poorest student.

Consideration of Some of the Factors Which May Influence Success.

The factors which are studied in this connection to discover, if possible, their influence on achievement in general chemistry are: the size of high school from which the student graduated, the type of elementary school in which the student learned to read, the sciences studied in high school, whether chemistry is taken as a requirement or as an elective, and the relative achievement of men and women students. These items follow in order.

The Influence of the Size of High School From Which the Student Graduated.

In considering the question of possible influence which the size of high school from which the student graduated might have upon possible success in college chemistry, high schools with more than 19 teachers were arbitrarily classed as large high schools. Those with from 10 to 19 teachers were classed as medium sized high schools. Those having 9 teachers or fewer were classed as small high schools. Table III gives a summary of the data bearing on this point.

Table III—Chemistry Training Scores on Basis of Size of High School.

	Large H. S.	Middle H. S.	Small H. S.	Whole Group
Mean of CT1-A scores	38.80	34.46	29.97	33.97
Mean of CT1-B scores	67.80	58.42	55.02	63.10
Improvement	29.00	23.96	25.05	29.13
V. of CT1-A scores	68.72	69.83	64.23	66.67
V. of CT1-B scores	41.95	40.58	43.07	42.74

The data in Table III indicate that the students who graduated from the large high schools average higher on both forms of the Iowa Chemistry Training Test than those from either of the other types of high schools. The chances are about 93 in 100 of a real difference in favor of the average of the group who graduated from the large high schools over the average of the whole group studied, as indicated by the Training Test scores, Form B. There

are 86.5 chances in 100 of a reliable difference in favor of the average of the whole group over the average of those from middle sized high schools, and almost complete certainty of a reliable difference in favor of the whole group over the average of those from the small high schools.

There is no very significant difference in the variability of the three groups. The scores on the first Chemistry Training Test rank in the same order as those on the final form of the test. The greatest improvement was shown by those from the large high schools. Those from the middle sized high schools averaged 1.09 points lower in improvement than those from the small high schools. This difference is probably not high enough to be significant, but the difference between the large high schools and the middle sized high schools in this regard is about five times as great as that found between the middle sized high schools and the small high schools. These facts seem to indicate a fairly definite advantage in favor of the graduates of the larger high schools. This may be due, in part, at least, to the fact that the larger high schools usually offer more and stronger courses in chemistry and physics than the smaller high schools.

Influence of the Type of School in Which Student Learned to Read.

Among other factors which might influence success in the study of general chemistry in college, there may be considered the type of school in which the student learned to read. In this study it has been assumed that the student learned to read in the type of school in which he did his elementary school work. In order to secure the data for this, as well as certain other parts of this study, each student was asked to fill out a simple questionnaire in which the desired facts were called for. For the purposes of this study schools were divided into rural, small town, and city school systems. Table IV gives a summary of the data bearing on this point.

Consideration of Table IV shows that students who learned to read in the city school systems seem to have the ability to score higher than other students on both forms of the Iowa Chemistry Training Test. On both forms of this test there is almost complete certainty of a reliable

TABLE IV—CHEMISTRY TRAINING TEST SCORES ON BASIS OF TYPE OF SCHOOL IN WHICH STUDENTS LEARNED TO READ.

	Rural Group	Small Town Group	City Group	Whole Group
Mean of test CT1-A	35.55	30.80	40.79	33.97
Mean of test CT1-B	57.52	63.14	70.92	63.10
Improvement	21.97	32.34	29.95	29.13
V of test CT1-A	54.28	87.53	62.98	66.67
V of test CT1-B	36.89	44.85	33.94	42.74

difference in favor of the mean of the city group over the whole group studied. There are 99.5 chances in 100 of a real difference on the first form of this test in favor of the mean of the rural group over the mean of the whole group, while on the second form of the test the chances are practically 100 in 100 of a real difference in favor of the whole group over the rural group. On the first form of this test there are 87 chances in 100 of a real difference in favor of the mean of the whole group over the small town group, while on the second form of the test there are 55.5 chances in 100 of a real difference in favor of the small town group over the mean of the whole group. The small town group shows much greater variability than the others, while the city group and the rural group are both somewhat less variable than the whole group.

The Influence of the Science Studied in High School.

Chemistry teachers and others have often made observations concerning the success in general chemistry in college of students who studied chemistry in high school, but comparatively few systematic observations have been reported on this point. Table V gives a summary of the data obtained on this point, indicating the possible influence of the science studied in high school upon success in general chemistry during the first term of study of the subject

TABLE V—CHEMISTRY TRAINING SCORES ON BASIS OF SCIENCE STUDIED IN HIGH SCHOOL.

	Chem. Group	Physics Group	Biol. Group	Gen. Sci. Group	Whole Group
Mean of test CT1-A	54.96	40.38	34.03	35.30	33.97
Mean of test CT1-B	85.14	68.58	55.00	59.43	63.10
Improvement	30.28	28.20	20.97	24.13	29.13
V of CT1-A scores	52.64	68.64	61.42	70.68	66.67
V of CT1-B scores	36.01	44.97	52.96	43.56	42.74

in college, as measured by the Iowa Chemistry Training Test.

The whole group of subjects was divided into groups on the basis of the science studied in high school. Thus, a student who had studied chemistry in high school was placed in the chemistry group regardless of what other science he may have studied.

Table V gives a fairly definite indication of the superiority of the chemistry group over the average of the whole group. There is practical certainty of a real difference in favor of the mean of the chemistry group over the mean of the whole group on both forms of the Chemistry Training Test, the chances being slightly higher in the first form than on the second form of this test. These results agree with those of Currier who states that "the student who had studied chemistry in high school had a decided advantage over the one who did not."[3]

In the physics group, the chances are 99.9 in 100 on the first form of the test, and 94 in 100 on the second form of the test of a reliable difference in favor of the physics group over the mean of the whole group. Thus, those who have studied either chemistry or physics in high school tend to score higher than the average student on the Iowa Chemistry Training Test in college. There is, however, a slight tendency for both of these groups to lose the advantage gained by their previous experience with these sciences in high school during their first quarter of study of general chemistry in college.

There is no significant difference in the achievement of the biology group and the average of the whole group on the first form of the training test, but, on the second form of this test, there are 97 changes in 100 of a reliable difference in favor of the whole group over the biology group.

In the case of the general science group, there are 72 chances in 100 of a reliable difference in favor of this group over the average of the whole group on the first form of this test, while on the second form of this test, there are 92.5 chances in 100 of a reliable difference in favor of the whole group over the general science group.

[3]Currier, A. J., "The Sectioning Problem in General Chemistry," *Journal of Chemical Education*, Vol. VIII, (1931), p. 330.

It is recognized that, in some cases, at least, these data are probably not conclusive, largely because of the relatively small number of cases involved. It is felt, however, that they do indicate definite trends.

Only 23.2 per cent of the subjects had studied high school chemistry, and 32.9 per cent of them had studied high school physics. Of those who scored in the upper fourth on the first form of the Chemistry Training Test, 61.7 per cent had studied chemistry in high school. Of those who scored in the lower fourth on this test, only 2.63 per cent had studied chemistry in high school. Of those who scored in the upper fourth on this test at the end of the term, 49.3 per cent had studied chemistry in high school. Of those who scored in the lower fourth on this test, 6.2 per cent had studied chemistry in high school. It is possible that the decrease in the percentage of those in the upper fourth and the increase in the percentage of those in the lower fourth who had studied chemistry in high school may indicate a tendency for this group of students to lose the advantage gained by their having studied chemistry in high school.

It was not the purpose of this study to determine the exact cause of this loss noted above. It seems certain, however, that many students who have studied chemistry in high school, when placed in classes with students who have a lower achievement level in the subject, are not stimulated to put forth their best efforts. The results are, in many cases, that the student who starts with a decided advantage tends to lose that advantage to the student who, though starting at a disadvantage, is stimulated to do his best. Probably the one tends to develop poor study habits and, in many cases, indolence and indifference toward his work in chemistry, while the other really learns how to study the subject.

The greatest improvement was shown by the chemistry group, followed by the physics group, the general science group and the biology group in the order named. The chemistry group shows the lowest variability on both forms of the test. The variability of the physics group was next to the highest on both forms of the test, it being exceeded by the general science group on the first form of the test, and by the biology group on the second form of the test.

The Influence of Chemistry as an Elective or a Required Subject.

Where chemistry is taken as an elective subject it was found that there are 74 chances in 100 of a real difference in the mean Chemistry Training Test scores in favor of this group over the mean of the whole group studied. Where chemistry is taken as a requirement the chances are 73 in 100 of a real difference in favor of the mean of the whole group over the mean of this group on this test. The chances are 84 in 100 that those who take chemistry as an elective will score higher on the Chemistry Training Test than those who take it as a required subject.

The Achievement of Men and Women in Chemistry.

Table VI gives a summary of the data bearing on the question of the difference in the ability of men and women students of this group to achieve in the study of general chemistry. The groups of men and women in this group are not strictly comparable in that the majority of the women took the subject because it was a requirement in their curriculums, while a majority of the men took it as an elective. In addition to this, more of the men had studied chemistry and physics in high school. The men constituted approximately 60 per cent of the group.

TABLE VI—ACHIEVEMENT OF MEN AND WOMEN ON THE CHEMISTRY TRAINING TEST.

	Mean	Coefficient of Variability
Whole group on test CT1-A	33 97	66.67
Men on test CT1-A	38.07	64.85
Women on test CT1-A	27.88	51.54
Whole grp. on test CT1-B	63.10	42.74
Men on test CT1-B	67.23	41.62
Women on test CT1-B	56.53	40.32

There are 96.5 chances in 100 of a reliable difference in favor of the mean of the men over the mean of the whole group on the first form of the Chemistry Training Test, and 95 chances in 100 of a reliable difference in the same direction on the second form of the test. There is almost complete certainty of a reliable difference in favor of the mean of the whole group over the mean of the women on both forms of this test. The men show somewhat greater improvement than the women, but not much above that of

the whole group. While the data available in this study are too meager and there are too many factors involved to warrant definite conclusions, there are fairly clear indications that the men of this group tend to succeed better than the women in the study of college chemistry.

CONCLUSIONS.

The facts observed in this study seem to warrant the following conclusions:

1. The average student of general chemistry in college is able to score about 18 per cent of the possible score on the Iowa Chemistry Training Test at the beginning of his study of the subject in college.

2. There is extreme variability in the scores of students on the Iowa Chemistry Training Test, both at the beginning and at the end of the first quarter of study of the subject in college.

3. The achievement level of the group studied, as measured by the mean scores made on the Iowa Chemistry Training Test, practically doubled as a result of one quarter's study of the subject in college.

4. A study of teachers' marks indicates that about 50 per cent of the group would most probably score between 74 and 87 per cent.

5. The average intelligence quotient of this group, as measured by the Otis Test, was 105.94, with a standard deviation of 10.33. The range was from 79 to 131.

6. Students who graduated from the larger high schools seem to have the ability to score higher on the Iowa Chemistry Training Test than those who graduated from smaller high schools.

7. Students who learned to read in city school systems (over 3000 population) seem to have the ability to score higher on the Iowa Chemistry Training Test than those who learned to read in either rural schools or small town schools.

8. Students who studied chemistry in high school tend to score higher on the Iowa Chemistry Training Test, both at the beginning of the term and at the end, than those of the whole group studied, though there is a definite tendency for that advantage to decrease during the term.

9. Those who have studied physics in high school tend

to score higher on the Iowa Chemistry Training Test than the average of the whole group studied, both on the first form and the second form of the test, though there is a definite tendency for this advantage to decrease during the term.

10. Those who studied biology in high school, and those who studied general science in high school, tend to score lower on the Iowa Chemistry Training Test than the average of the whole group.

11. Those who take chemistry as an elective subject tend to score higher on the Iowa Chemistry Training Test than those who take it as a required subject.

12. There is a definite tendency noted for the men students to score higher than the women on the Iowa Chemistry Training Test.

(Note: The schools cooperating in this study were the Northeast Missouri State Teachers College, Kirksville, Mo.; the Central Missouri State Teachers College, Warrensburg, Mo.; the Southwest Missouri State Teachers College, Springfield, Mo.; the Southeast Missouri State Teachers College, Cape Girardeau, Mo.; and Culver-Stockton College, Canton, Mo.)

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,
The University of Oklahoma, Norman, Okla.

While the scientific world is recovering from the shock of a great experimental discovery, there is generally a reaction, when explanations are showered upon it intended to demonstrate that so far from being surprising, the new discovery is exactly what ought to have been predicted.—*Arthur Schuster, "Progress in Physics."*

The percentage of freaks among people in general is very considerable, but it is especially high among teachers.—*Leon Trotsky, in "My Life."*

In a great soul everything is great.—*Blaise Pascal, "Discourse on the Passion of Love."*

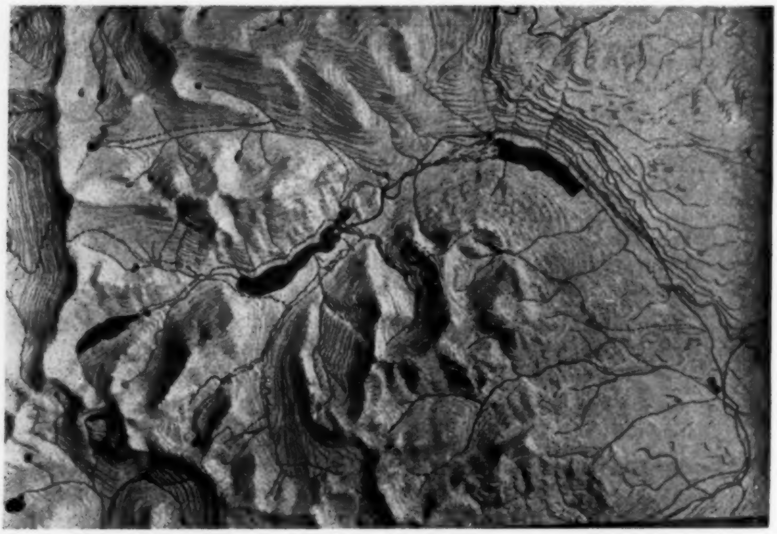
It has been my observation that though scientists are often men of none too admirable conduct they are usually honest enough with themselves and with their fellows to recognize their real motives and to frankly admit them rather than to make to themselves and to others dishonest pretenses.—*Robert Andrews Millikan, in "Why Study Physics?"*

It is said that the English Puritans objected to bear-baiting not because it hurt the bears, but because it amused the people.—*Durant Drake, professor of philosophy at Vassar College, in "The New Morality."*

A PROJECT IN RELIEF MODELING.*

BY VIVA DUTTON MARTIN,
Arsenal Technical High School, Indianapolis, Ind.

For three summers Mr. Martin and I have been checking Rangers at the entrance of the Many Glacier Valley, Glacier National Park. Among our various duties was that of giving information concerning the valley and directing tourists to various points of interest in the area. We tried the excellent United States Topographic Maps of the Park, but a very large per cent of the people could not read the map. We had to find some way of conveying information concerning the area to the people who needed it. We considered ways and means and finally evolved the plan of the model which is shown in the picture; the actual model was presented at the Austin High School during the Chicago meetings of the Association. Our first model was of the Many Glacier Valley; the second, of the Two Medicine Valley which is the one shown in the illustration.



The authors make no particular claim to originality in the general idea of the model, but there are some useful and practical adaptations which may be helpful to some-

*Read at the Geography Section, Central Association of Science and Mathematics Teachers, Austin High School, Chicago, November, 1931.

one else in making a relief model. The outstanding merit of the model is that it is made to the *same* scale both horizontally and vertically which construction results in absolute accuracy of slope and correct proportion in every particular.

The first step in making the model was to have the desired area, over 120 square miles, of the U. S. Topographic Map enlarged to four times its original scale giving a map of scale, one inch equals one half mile, and size 19"x24". Two copies of this enlargement were used; one for cutting, one for checking. These enlarged maps were used directly as the basis for the model. The vertical scale was the second matter of concern. The contour interval of the U. S. Topographic Map is 100 feet. Using the horizontal scale one inch equals one half mile, computation was made of the necessary thickness of a layer of cardboard which would exactly represent 100 feet. A micrometer was set for the computed thickness and was used in testing sheets of cardboard until the right number of ply was found. (A wholesale paper company had to be consulted.) The thickness of this cardboard was such that it made cutting it with shears an arduous process productive of numerous blisters, but the accuracy of the vertical scale was maintained regardless of the cost! A special printer's paste, which dries to a negligible thickness, was employed to stick the layers of cardboard together. Ordinary paste or glue accumulates to an appreciable thickness where so many layers are used and such a small scale is employed. The base of the model consisted of a four-ply veneer board to prevent warping. The first layer of cardboard was not only glued but tacked to the board to prevent the drawing of the paste from pulling the sheet loose later. The base was then ready for the model itself.

The map was cut out along the lowest contour line. The cut map was then placed on a sheet of cardboard and the cut portion outlined on the cardboard. This outline was cut out; the sheet placed on the prepared base, checked with the original map, and then pasted. Weights were placed on the pasted portion and left for some hours. Two sheets, seldom more, were pasted at a time. The map was then cut along the next contour line, marked on the card-

board, cut, checked, and pasted as in the previous case. This process was repeated until the entire map had been built up on the model.

The completed model was shellacked to keep the paste dry and prevent warping. Later the model was given two coats of white lacquer which smoothed out the steps between the layers of cardboard just enough to give a very realistic effect for the formations of the area are sedimentary, a large part of which is still in a nearly horizontal position. Plaster of Paris made an admirable likeness of the glaciers which dot the cliffs. The drainage was put on in blue lacquer; trails and roads, in black; and tiny wooden models represented hotels, chalets, and Ranger Stations.

The model was mounted in a wooden case with a glass cover just high enough to clear the peaks. On this glass appear the labels of drainage features, peaks, and culture, so placed that they appear in the correct location when viewed from above. This method of labelling leaves the relief unmarred by nomenclature.

These models met our need admirably. Practically everyone was able to understand directions pointed out on the actual relief of the model. So accurate was the model that the Alpine guide came to it to plan the ascent of new peaks.

In the class room the models have proved most valuable in helping the students to vizualize contour maps, understand cross sections, and recognize various mountain forms, and relief features and drainage conditions resulting from glaciation.

Such a model of a less complex area might profitably be made by a group of students, each one cutting and pasting a certain number of layers. A group could make such a model at a modest cost in a short time, learn a great deal in its construction, and have as a result a permanent model for the laboratory of no small value.

A new subspecies of kinkajou, an attractive little animal that climbs its own tail like a rope when it is tired of hanging monkey-fashion from a limb, has been discovered in Costa Rica and is described by Dr. E. W. Nelson and Dr. E. A. Goldman of the U. S. Biological Survey, in a report to the Washington Academy of Sciences.

TEACHER OPINION AND SUGGESTION ON TEACHING UNITS IN PHYSICS.

By A. W. HURD,

Institute of School Experimentation, Teachers' College, Columbia University.

The questionnaire data presented in this article were obtained from 43 returned questionnaires from teachers who had experimentally used a teaching unit in high school physics with one or more classes during the school year of 1930-31. The unit topic was "Electric Lighting Systems" and the teaching time specified varied from 17 to 23 periods depending on the particular experiment selected.[1] Two years of experimentation preceded the series of 1930-31. The general purpose of all the series of experiments was to discover better materials and methods in high school physics. This summary of questionnaire responses should be of value because the responses are from teachers who were interested sufficiently to try out an experiment and express opinions after at least 17 teaching periods spent in attempting to secure satisfactory pupil achievement on the specific objectives set forth in the unit outline. It may be well to note that the unit outline was the third revised edition of the unit originally designed for the series of experiments and, therefore, represented an advanced stage in its use. Moreover, some of the teachers whose opinions are presented were in the third successive year of experimentation.

The first question sought to discover whether the full amount of time specified in the directions for the experiment was actually used. In experiments of the kind attempted, time is "of the essence" and it was desired that no conclusions might be drawn from experimental data premised upon a stated time, if the time were not actually held constant as intended. Of 40 responses to this question, 36 stated definitely that they had used the specified time and 4 that they had not. Reasons given for not using the specified time were that particular local conditions prevented it. In no instance was a longer time used, however. Generally, teachers may be depended upon to follow experimental directions as to time involved, when this is

[1]Outlines of these experiments may be found in the North Central Association Quarterly 5:485-89, March, 1931.

stated definitely. In this connection it is well to realize that in cooperative experimentation, directions should be stated distinctly and definitely and conclusions should be based on all the data available. Sometimes a seemingly inconsequential deviation from directions may introduce an experimental factor of great importance. Certainly the time element in the experiments under discussion is a vital factor in pupil achievement.

The directions for all experiments specifically stated that all out-of-class time was to be reserved for project work; in other words, no lesson assignments or home work on the *minimal essentials* or *common activities* were to be assigned to use up out-of-class time. This is a distinct innovation in procedure especially in physics. Of 41 teachers responding, 24 followed the directions by not assigning outside lessons; 13 did not follow the directions for they regularly assigned outside lessons; and 4 tried to follow the directions in the main, though they assigned a few outside lessons.

A check on this item was made by inserting the question, "Did you reserve all out-of-class time for project work?" Of 39 responding, 18 said "Yes"; 15, "No"; 2 said they "did not reserve all outside time but did reserve most of it"; and 4 said "No project work was done."

These two items show that teachers engaging in the cooperative experimentation will not universally follow innovations. This may be because of not thoroughly comprehending the details of the directions, or because of a strong inclination not to depart too far from the more conventional procedures followed in the past. In judgments of the data from the experiments, it cannot be implied, therefore, that the records obtained are necessarily dependent upon the adoption of a minimal essential-project program. The important point here is that even though teachers are interested enough to engage in experimentation, they cannot be depended upon to depart far from conventional plans and methods without more studied preparation on the part of the experimenters. Though the directions were specific enough on this point, and all teachers promised to follow directions, more than a third did not do so. There is strong indication, however, that the reason in this

case was largely because the innovation was not thoroughly comprehended as essential by all cooperating teachers.

In view of the difficulties teachers of physics have had in attempting to cover the ground of the conventional course in physics, an added project program is not welcome. Its adoption means that achievement records on the conventional content will be just so much less satisfactory than they are at present. However, in connection with these experiments, the project program has received a considerable stimulus as may be seen by the responses to the next item, "Summarize the special individual project work in which pupils engaged." The following tabulation gives some conception of the extent of project work. The figures give the number of individual pupils so far as they could be judged from the responses obtained:

Investigate primary battery types	5
Investigate methods of connecting cells in a battery	3
Study of voltaic cell	1
Making a voltaic cell	1
Experiment with dry cells	15
Setting up type cells	1
Visit storage battery plant	9
Investigate construction of storage batteries	1
Report on storage battery	1
Investigate the history of lighting	8
Investigate the history of arc lights	15
Investigate the history of the incandescent lamp	4
Report on the life of Edison	1
Biographical report	1
Report, "The Man Who Gave Us Light"	1
Report on incandescent lighting	1
Report on arc lighting	2
Report on electric lighting in the home	1
Study "Wiring in an Automobile"	2
Study "Electric Plant Current Generation"	4
Study "Household Electricity"	1
Study "Construction of Watt Meter"	1
Report on power plants	4
Study electric motor	1
Study electro-magnetism	1
Study electrical units	1
Study home appliances and	
Paper on "Economic Values of Electricity"	1
Report on generators	1
Report on ammeters	1
Report on rectifiers	1
Report on street lighting	1
Book review	1
Report on building codes	2
Report on lighting system of auto	1
Investigate cost of lighting	1
G. E. Film Lecture—Searchlights and Flood Lighting	1
G. E. Lecture—History of Electric Lighting	1
G. E. Lecture—Industrial Lighting	1
Study the use of electrical measuring instruments	1
Study the construction of transformers	1
Visit electric research laboratories	4
Visit electric light plants	21
Visit electric R. R. substation	25
Trace building bell circuits	1
Make diagrams	1
Diagram house lighting	1
Make an arc light	4
Make an electric furnace	2
Build a lamp bank	1
Build a simple generator	1
Build a simple motor	7
Rewind old motor	1
Make a portable electric rectifier	1
Repair electric bells	2
Wire home appliances	1
Repair laboratory equipment	5

power used	1
Investigate mercury turbines	1
Investigate kinds of radiations	1
Study generators	1
Investigate condensers	1
Investigate the electron theory	1
Investigate local electric plant	16
Report on periodical articles	7
Study efficiency of electric lamps	1
Read references	3
Study therapathy	1
Investigate stage lighting	1
Report on home and industrial applications	1
Report on wiring codes	1
Report on television	3
Paper on "Electricity of the Future"	1
Paper on "Household Appliances"	1
Paper on "Production, Transmission, and Distribution of Electricity"	1
Paper on "Lighting Arrangements"	1
Paper on "Commercial Lighting"	1
Paper on "School and Home Lighting"	1
Make a transformer	1
Change arc to incandescent lamp projection machine	1
Wire "set ups"	2
Make a thermo-couple	1
Set up three way switch light	1
Prepare electric circuits	2
Demonstrating Foot Candle Meter	1
Demonstrating apparatus brought in	1
Study Methods of connecting wires	1
Scrap book	6
Demonstrate light sensitive cell	1
Demonstrate model arc lamp	1
Extra laboratory experiments	7
Finding the resistance by Wheatstone Bridge	7
Laboratory work on the measurement of current, voltage, resistance, and power	2
Laboratory experiment—Efficiency of lamps and motors	1
Demonstration on heating effects of electric current	1
Demonstration: "Lamps in Series and in Parallel"	1
Experiment on Cost of running a percolator	1

Other responses to this item were less specific. For example, two instructors stated that each pupil did one extra project. One said that his pupils were requested to find some interesting topic to develop.

It will be noticed that there are a relatively few types of projects which are suggested. They are in the nature of (1) the study or investigation of certain things, (2) making reports, (3) reading articles or books, (4) field trips, (5) demonstration, (6) construction, or (7) experimentation. Pupils are interested in doing some of these things if they are given time for them. The problem at present is to reserve sufficient time in the pupil's program so that he may have the opportunity of following his inclinations in some purposeful project work.

The next two items sought teacher opinion on the time desirable for the unit if available. Of 41 responses, 28 thought more time was desirable; 2 thought it was desirable for some pupils; 1 was uncertain; and 10 thought the time allotment sufficient, or too long. It must be noted that the time allowed is greater than that usually provided for on equivalent content.

Of 40 responses on how much time would be ideal in order to secure satisfactory achievement ratings, the following tabulation shows the various judgments:

As planned (18 or 23 periods)	8	3 to 5 added periods	1
12 days	1	5 added periods	1
13 days	2	26 periods	1
14 days	2	28 periods	1
18 days	1	30 periods	1
20 days	2	30 to 35 periods	1
21 days	1	1 week additional	2
20-24 days	1	At least 4 weeks	2
25 days	4	About 5 weeks	1
2 added periods	2	6 weeks	2
3 added periods	2	Till eternity	1

While there is some indefiniteness in terminology, it is readily discernible that teachers desire more time for the unit in order to secure more satisfactory achievement. At present the time allowed for the acquisition of important concepts is too restricted.

The next item seeks to direct attention to possible values of reserving out-of-class time for project work and asks opinions of teachers on this matter. The tabulation of responses follows:

Gives unlimited time	4	Pupils learn the use of the library	1
Gives time to read periodicals	1	Relates work to local conditions	1
Gives bright pupils a chance to branch out	3	Education not only a classroom affair	1
Gives contacts with new material	1	Gives opportunity for drill	1
Develops scientific attitude	2	Broadens viewpoint	1
Stimulates interest	10	Gives chance for vocational guidance	1
Gives a chance for a hobby	2	Makes pupils respect subject matter	1
Teaches self-reliance and resourcefulness	4	All work sure to be their own	1
Develops ingenuity	1	Makes for freedom of work	1
Stimulates observation	1	Very little for most pupils	1
Develops initiative	5	Doesn't work with our study hall plan	1
Gives opportunity for more thorough study	1	None	1
Cultivates wise use of leisure	1	Students here not strong on projects	1
Makes various projects possible	1		
Makes physics practical	1		
Helps to build background	1		

The responses indicate a general appreciation of the advantages of allowing ample time for individual project work. The two outstanding phases mentioned are that it stimulates interest and develops some important character traits. Judged by the last four statements, a few do not believe in the use of projects in physics. It is a question if this may not be on account of an already overcrowded

program. Perhaps, if a project program were made feasible and its importance emphasized, all would be won over to its values.

The next item was, "Are your pupils interested in work-sheets?" Of 94 classes whose records were received before this article was written, 81 used work-sheets. The work-sheets were designed to aid in raising achievement ratings on carefully selected concepts. It is important to know whether or not pupils liked the work-sheets. The following is a tabulation of responses:

Very much	6
Yes	25
Moderately	1
Especially the better pupils	1
Some pupils like them	2
Especially the class using them	1
Much at first	1
Not exceptionally	4
No	2

Apparently they may be used with most classes so as to stimulate interest though some teachers do not favor them. This may be because of unsuitable or improper use.

The next item was, "State your opinion of the advantages of work-sheets." The tabulation of responses below will help to make clear the functions of work-sheets:

Work is definite	10
Individualizes work	6
Calls attention to the main points	4
Organizes material	3
Forms a definite work plan	3
Makes for definite assignment	1
Helps to motivate work	2
Suggests additional work	2
Summarizes work	1
Condenses material	1
Brief, orderly, and complete	1
Makes work uniform	1
Unifies work	1
Provides a definite minimal requirement	1
They save time	2
Makes for more accurate information	1
Review	1
Drill	1
Reference	1
They guide wisely	1
They eliminate confusion	1
They eliminate duplication	1
Teach self-reliance	1
Develop appreciation	1
Get away from text-book	1
Less writing	1
Discovery of various source materials	1
Makes reading purposeful	1
Good means of checking pupil progress	1
Secures greater pupil activity	1
Not advantageous—difficult to motivate	1
None based on results obtained	1
I am not keen on contracts	1

The responses speak for themselves and suggest how work-sheets may best be used. They cannot be expected to remedy all defects of instruction, but they may serve useful purposes if used with these purposes in mind.

Instructors were next asked to make suggestions for improving the work-sheets. Altogether 62 suggestions were made. They refer almost exclusively to additions. In most

cases these suggested additions are included in other units of instruction, which are portions of nineteen units outlined for a course in high school physics. Many of those using this unit were not acquainted with the whole series or they would not have made many of the suggestions. There are a few who suggest rearrangements within the unit. This is always a questionable matter and should be decided largely on the basis of pupil achievement records. For example, if records are not satisfactory, reasons may be sought in the arrangement of materials in the work-sheets used. Some of the suggestions will be utilized in a future revision of the work-sheets. They will probably not be worth quoting here.

The series of experiments were instituted largely to increase achievement ratings on important concepts in physics. The next item made inquiry concerning means for securing more satisfactory achievement ratings. The following are suggestions made:

No answer	9
Develop the work-sheet method	5
Create interest	4
More laboratory work	2
More pupil application to work	3
Assign extra work	2
Assign lessons out of class	2
Eliminate some of the present program	2
More individualization of work	2
More lecture and demonstration	2
Have better texts written	1
More drills and reviews	1
Give slow pupils personal attention	1
Require a project of everyone	1
Eliminate some of the extra curricular work	1
Emphasize one topic at a time	1
Longer time, fewer units	1
More student participation	1
More explanation	1
Stress applications in pre-view	1
More class discussion	1
More equipment	1
More definite study	1
Cover all test material in class	1
Allow projects during class time	1
Section pupils on ability basis	1
Correlate physics with English	1

There seems little consensus of opinion here, though one could deduce something like this which would probably receive the endorsement of most; viz., concentrate the attention of pupils on the relatively more important concepts and get them to apply more studious effort by creating interest and satisfaction in achievement. There is nothing new in this suggestion but it is safe to say that we have not yet succeeded in acting upon it in great enough degree. These experiments are attempts to do these things and evaluate the results obtained. After three years of experimentation, we can safely say that though improvement has

been marked during the series of the current year, there is still much to be done.

The concentration of attention on the more important signifies that the less important may be eliminated. The next two items raised the question of possible elimination from the unit as outlined in its latest form. Of 33 responses, 14 thought some further eliminations possible; 14 thought no further eliminations advisable; 3 thought very little possible; and 2 knew of none to suggest. Considering eliminations based on functional use in everyday life, of 56 suggestions made, 16 said, "eliminate none"; 9 said, "eliminate the comparisons of power and work units"; 12 said, "eliminate much of the material on arc lamps"; 4 said, "eliminate water and temperature analogies to electric currents"; 3 said, "omit reference to streetcar lighting systems"; 2 said, "omit material on the history of lighting development"; and 2 said, "omit social and citizenship references." Other suggestions were scattered and relatively detailed. They are probably not worth quoting here. Altogether the suggestions made will make a further revision possible which will probably meet with quite general approval.

There has been objection in some quarters to using the ultimate objectives of education as stated by the North Central Association of Colleges and Secondary Schools as criteria for selection of material for the course in physics. Therefore, the next item asked instructors if they thought these objectives helpful in selecting material. Of 39 responding, 8 said, "very much so"; 30 gave an unqualified yes; and 1 said, "not much." This is practically unanimous opinion on the usefulness of these objectives; i. e. sociological objectives in selecting material for the course in physics.

The next item reads, "Is there great value in the consideration of the immediate purpose of such pupil activity as one for information, appreciation, techniques, or habits and skills?" These are abbreviated editions of the immediate objectives of education as stated by the North Central Association of Colleges and Secondary Schools. Of 37 positive responses given, 30 were yes; 3 were no; and there was 1 for each of "Don't know," "Not great," "Not to the

pupil," and "Especially appreciations and habits."

The following item inquired why these immediate objectives were thought helpful. Of 28 understandable statements, the following are most important judged by their frequency:

Make objectives definite	10
Provide motivation	7
Relate theory to practice	2
Attitude is primary	2
Make for more careful selection	1
Make teaching meaningful	1
Make the subject a live one	1
Make methods more obvious	1
Make measurements of progress easier	1
Contribute to good citizenship	1
All three are necessary	1

Many ambiguous statements and no answers showed this item to be a little unusual, to say the least. In other words, it is doubtful whether teachers customarily think of objectives other than those for information. Probably if more attention was paid to the immediate purpose in mind for given activities, better and more thorough teaching would result. It seems reasonable to conclude that if an appreciation were the objective sought for, for example, the procedures used to attain it would be different than those for information or a technique. Teachers of physics generally do not clearly differentiate between information, appreciation, techniques, and habits and skills, and it might help considerably if more studied differentiation was made.

Instructors were next asked to what extent pupils used the reference books, other than texts, which were listed. The 37 replies were as follows:

Used considerably	12
Used all we had	6
Used very little	5
We had few	4
Used not at all	3
Some used them	2
Some use for projects	1
Used much by successful pupils	1
Special assignments	1
Used for work-sheets	1
Used by about 50%	1

There has not been wide use of reference books in the course in physics in the past. This probably is largely due to the great extent of the material ordinarily considered in the course. It seems clear that there should be wider use of reference material and if outlined units with listed references come to be more common and time is provided for pupils to read the references, the practice will increase.

The last item inquired as to the use of the textbooks listed at the beginning of the unit. The responses showed that it is becoming more common to use more than one

textbook for reference, though practice is largely to use but one text and to follow it quite closely. The use of outlined units built around topics with references to several texts and lists of popular books not intended for texts will gradually bring about less dependence on a single text. For extensiveness, this is probably desirable but perhaps, for careful and intensive work, not always indicated.

SUMMARY.

The concepts which apparently stand out from the analysis of the questionnaire returns from 43 teachers who had used an experimental unit in physics are as follows:

1. Teachers may generally be depended upon to follow experimental directions concerning the time to be used in teaching the unit if it does not depart too decidedly from general practice.
2. Without some special precautions teachers cannot always be depended upon to follow experimental directions which depart considerably from general practice.
3. A minimal essential-project program is probably not a common practice in physics. It has possibilities, however, if time is made available for use by the pupil. Many pupils enjoy the project opportunities and make valuable use of the time given for them.
4. Too much is being attempted in the physics course for the time allowed. Teachers generally advise more time if more satisfactory achievement is to be expected.
5. Many teachers believe that time reserved for individual project work stimulates pupil interest and develops important desirable character traits.
6. Most pupils are interested in work-sheets when used as in these experiments.
7. Work-sheets serve to make the work definite and concise. They are usually helpful when used properly, but cannot be depended upon to remedy all the defects of poor instruction.
8. There is need for careful preparation of work-sheets so that they best serve the purposes for which they are adapted. They should be definite and concise and devised to sustain the interest of pupils using them.
9. More satisfactory achievement ratings may be obtained if pupil attention is concentrated on the relatively

more important concepts and effort is stimulated through arousing and sustaining pupil interest and satisfaction.

10. At present elimination of the less important should be emphasized rather than additions to an already overcrowded course in physics.

11. Teachers generally realize the importance of the sociological objectives as criteria for the selection of material for the course in physics.

12. Generally speaking, teachers do not give enough attention to the specific worthy purpose of each pupil activity. Studied analysis of why pupils should be asked or led to do this and that should result in activities more clearly designed to accomplish a definite purpose. Worthy immediate objectives in physics are definite information, definite appreciations and attitudes, and definite techniques.

13. The use of supplementary reference books in physics is probably not widespread. Carefully planned teaching units with suggested references may be depended upon to stimulate a wider use.

14. The use of many textbooks in classes in physics is probably not a common practice. There are values in using more than one book but it may result in superficiality. For intensiveness, a single text may be valuable.

It is hoped that the discussion of these questionnaire returns may, by stimulating thought, bear fruit in securing better materials and methods in high school physics and perhaps indirectly aid in improving other school courses.

THE SCHOOLS AND UNEMPLOYMENT.

If the 1930 ratio per cent of school attendance to population for persons 16 and 17 years of age had remained the same as for 1920, more than 671,000 young people now attending school would be out of school and would be potential competitors with the adult group for employment.

Among the factors contributing to increased school attendance are the increase in the amount and character of vocational training offered in the public schools; the increased age for compulsory school attendance and better enforcement of attendance laws; increase in age at which youth is accepted into employment mainly because of increased need for technically trained and skilled workers; the increasing use of power machinery which tends to eliminate unskilled labor; and the growing recognition by students, parents, and employers of the practical value of the educational training offered in the upper years of the public-school curriculum.—*Report by Dr. Maris M. Proffitt, Federal Office of Education.*

PRACTICAL AVOCATIONAL SCIENCE.

By Bernal R. Weimer,
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The advice of Agassiz to "study Nature, not books" has been with us a long time. So long, in fact, that its very familiarity has bred a sort of contempt for its wisdom. The consequent result is that instead of studying nature at first hand under natural conditions, there has been set up the largely artificial conditions of the laboratory. Today it may be truly said that biology is not only too formalized but entirely too "formaldehyzed" as well.

However, in this day of standardized pre-professional and professional courses with the consequent emphasis on the purely vocational, it is little wonder that the content and aim of science courses have shifted to the purely practical, economic, fact-accumulating end. The student is being trained only to make a living rather than how to live.

Within the past few years there have appeared several challenging books on the problem of leisure time and how to use it most effectively for the enrichment of the individual and the welfare of society. Many economists and sociologists agree that the only solution for or amelioration of unemployment, unrest, and the host of social ills which have come with this present machine age, is to reduce the number of working hours and working days. This will tend to make more insistent this problem of leisure and how men shall live avocationally.

Recognition was given to this problem back in 1918 in the report of a committee of the National Education Association which emphasized "the worthy use of leisure time" as one of the cardinal principles of secondary education. Doctor Goodwin Watson (The World Tomorrow, 1930) in his suggested reorganization of the high school, would create a Department of Leisure and states further that the "really challenging task for education is the enrichment of leisure." It would seem that the various departments of the colleges and universities would see this problem, make another survey of themselves—one more will do no harm—and, if possible, make

some definite contribution toward solving this problem of increased and often misused and abused leisure.

If curriculum changes were planned to meet this need, it would seem that the content and the procedure followed in such courses must of necessity differ in some respects from the usual "line run" of courses. A new technique becomes imperative. A course with avocational objectives cannot make use of the set, formal lecture type of instruction. Any influence with a tendency to deaden or restrict freedom must be removed. The spectre of "grades" must be securely locked in the closet and the greatest possible allowance and freedom given for the various individualities touched.

To be most effective, the content of the course must appeal to the individual—"spirit, mind, and body"—and must have carry-over qualities for use in later years. It should outline and arouse an interest which would involve little expense to pursue and, finally it must be absolutely free from any economic urge.

The field of Natural Science seems to afford the background for a college course which would admit all the qualifications suggested above. For such a course the world roundabout would serve for both laboratory and classroom. This of itself would make for that natural freedom which is so desirable and bring the added interest which is always attached to something alive.

Perhaps it may be of greater interest and make for more objectivity if a course of this type were outlined. Such a course is offered at Bethany College and styled in the catalog of the institution as Our Outdoors. The catalog statement specifically states that the course has no practical or economic aim but is outlined as "a series of field studies on plant life, animal life—particularly ornithology and entomology—physical geography, and training in the essentials of camping." Many institutions of higher education offer separate courses in ornithology, entomology, and these other fields just mentioned; but the average student has time, in his crowded "required" and vocational curriculum, for one or perhaps two of these courses. In most cases the instructor in charge is intensely interested only in his one particular

field which in itself narrows the boundaries of the course even more and restricts the range of interest. The most important aim of an avocational course is to enrich the field of interest for playtime pursuits. In place of turning out two-semester hour specialists who know more and more about less and less, the plan is to qualify avocationists who know more and more about more and more. The observation may be made that it will be less and less about more and more. However, it is felt that the content of the course can be enriched and strengthened in a large measure by the elimination of much of the lost motion attendant upon the usual field trip. Certainly no time will be lost searching for specimens to study and, should the organic specimens fail, there is the earth itself at hand.

To outline the course more fully no one teacher is responsible for all the various activities. It is a cooperative undertaking on the part of qualified members of the various scientific departments in the college coordinated and correlated by a director. All meetings of the group are held outdoors in the field. Along with the instruction in natural science and astronomy, is taught the practical elementary principles of camping; such as, selection of camp sites, camp sanitation and camp cooking. This part of the course is in charge of the Director of physical education. The program calls not only for study in the field but living outdoors as well. Week end camping trips are in the course schedule.

The adventure—for such is the spirit of this new departure—begins in midwinter. At this time of the year bird life is more easily studied for leaves are off the trees and migrant species are gone. There are no wild flowers and few insects. Thus there is lacking the multiplicity of life forms which are present at other seasons which, by their bewildering abundance, make the task of making their acquaintance seem hopeless to the novice and drives him back into the classroom to his books or to his "sessions" at the fraternity house. However, with the nucleus of nature knowledge gained in winter study, the stage is set for the many new floral and faunal arrivals which come with early spring. Most of the work

in geology, astronomy, and camping can be carried on during the winter as easily as in the spring and summer.

Doubtless there are many who will say that what has just been outlined is the same as has been carried on in the schools for many years as Nature Study. Yet there are several characteristics which seem to give new atmosphere to the course. In the first place the usual nature study course is knowledge-accumulating; whereas, this avocational science course has a decided habit-formation element in it. Again, the course outlined is more a correlated science course, a broad, overt attempt to get away from the usual compartment type of field course. In the next place, the students in the college group have more mature minds than those most often found in a course in nature study in the grades. It is coming to be recognized more and more that what really determines what and how much value is derived from a certain study, is the intellectual maturity of the pupil rather than the amount of material in the course.

The wide range of interests presented by these field studies of birds, insects, plants, stars, and rocks will make for freedom and development of interest by the individual. His field of playtime pursuits will be enriched and his scientific horizon widened. It is hoped that new hobbies will be found and developed which can be ridden while walking or camping in the sunshine or under the stars, and new interests aroused which will develop not only the mind but the body and spirit as well.

MAKES ARTIFICIAL LIMBS OUT OF SEAMLESS TUBE.

Charles H. Davies, mechanical engineer of Philadelphia, lost his leg in a mine accident when he was eleven years old. Today his ideas, which have been recently patented, are revolutionizing the manufacture of artificial limbs.

Shortly after the war, a report in the trade journal, American Machinist, discloses, Mr. Davies started making wooden legs. He found them clumsy and ill-fitting. Then he tried using various metals, but the riveted or welded joints were unsightly.

Finally, Mr. Davies conceived the idea of using an aluminum alloy, made into a light, seamless tube. He invented a type of hydraulic press to "blow up" this tube to take the desired shape.

Now the cost of metal legs is cut in half, and labor and time of production are reduced almost 100 per cent.—*Science Service.*

THE EFFECTS OF EXPLORATORY MATHEMATICS UPON FORMAL ALGEBRA.

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and
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Introduction

The agitation for the junior high school in this country brought out considerable discussion of the obligations that the school has in meeting individual differences, in developing interests, of exploring new fields, and of reorganizing the traditional departments of learning. The establishment and growth of this comparatively new educational institution have led to a large number of curricular changes. Long-standing departmental barriers have been broken down in favor of unit courses, fusion courses, and integrated courses, all the names having somewhat the same connotation.

In mathematics this reorganization has led generally to the following arrangement: the seventh year is devoted to a review of the fundamental processes of arithmetic, integers, common and decimal fractions, some work with formulas and graphs, and a considerable amount of intuitive geometry; the eighth year is given over to some difficult parts of commercial arithmetic and mensuration, and some algebra including equations, graphs, formulas and simple operations with positive and negative numbers; and the ninth year is usually taken up with formal algebra.

Setting of the Study

There are, no doubt, a large number of communities so circumstanced as in Niles, Michigan, where this investigation was carried out. The senior high school draws pupils not only from the junior high of the city, but a number also from the rural schools nearby and some transfer pupils. The junior high school organization has been in existence in Niles since 1922-23. The mathematics in the seventh and eighth years follows the exploratory or unified type; the ninth year is formal algebra. The content

of the general mathematics course in the seventh and eighth years has remained the same since its inception, although one change in textbooks has been made, and one change in textbooks for the ninth year algebra has been made. There has arisen among the mathematics teachers considerable question as to the contribution made by the exploratory courses to the formal algebra course. Some have raised doubts as to the emphasis, time spent, and amount of exploration that should be given.

It was discovered by comparison of the junior high mathematics course of Niles, and of the arithmetic of Berrien County, Michigan, from which the senior high school draws most of its pupils, that the content of the two courses was very similar. The one feature which was an exception to this statement was the presence of signed numbers in the junior high course, whereas they were absent from the rural course. There is, however, the added comment to be made in regard to thoroughness of treatment. Where the rural pupils get very brief treatment of most items in the course, the junior high pupils get a very much more thorough treatment. Precisely the amount of time devoted to instruction in general mathematics in the rural schools could not be determined.

The basis of comparison employed was teachers' marks over the period from 1924-25 to 1930-31. The letter system of marking, involving A, a, B, b, C, and D was in use in the years 1924-25 and 1925-26. The values attached in the computation were 4, 3.2, 2.4, 1.6, .8, and 0. Beginning with the school year 1926-27, a simplified letter system was employed, A, B, C, D, and E, with D the passing grade. The values attached were respectively 4, 3, 2, 1, and 0. The comparison of marks was made on the basis of composite algebra marks by the six-week and semester grading periods, averaging the results obtained in both the rural and junior high groups. Unfortunately, it was impossible to compare the rural and junior high groups as to intelligence, except for the one year of 1930-31. The average percentile rank on the Otis Group Intelligence Scale, Advanced Examination, Form A, for the rural group of 22 pupils was found to be 63.04, whereas for the junior high group of 68 pupils it was 69.02. Too much signifi-

cance should not be attached to this difference of 6 points because of the small number of pupils used in the calculation, and because they were all in the same year. Whether a comparable difference would be found for each of the other years cannot be asserted.

Findings

Table I gives a compilation of the average grades by six-week and semester periods for both the junior high and the rural pupils. In the calculation for the total averages, the grades for the years 1924-26, inclusive, were not included because of the difference in the marking system in vogue at that time. A number of observations may be made from an analysis of this and the accompanying table:

Table I—Average Algebra Grades by Six Weeks and Semester Periods

Years	Number	First Six Weeks	Second Six Weeks	Third Six Weeks	First Semester	Fourth Six Weeks	Fifth Six Weeks	Sixth Six Weeks	Second Semester
City Pupils									
1924–25	45	2.47	2.26	2.15	2.04	2.19	2.28	2.01	1.88
1925–26	54	2.59	2.41	2.38	2.36	2.12	1.90	2.22	1.88
1926–27	41	2.51	2.46	2.71	2.59	2.22	2.39	2.19	2.29
1927–28	54	2.48	2.39	2.46	2.44	2.26	2.19	1.96	2.06
1928–29	69	2.49	2.36	2.06	2.30	2.06	1.97	2.14	2.03
1929–30	63	2.54	2.51	2.65	2.56	2.43	2.41	2.44	2.37
1930–31	56	3.52	2.46	2.61	2.43	2.25	2.18	2.12	2.12
Ave. 1926–31	283	2.51	2.43	2.47	2.45	2.24	2.21	2.18	2.17
Rural Pupils									
1924–25	7	2.40	2.51	2.85	2.97	2.74	2.63	2.06	1.94
1925–26	13	2.22	2.09	2.15	2.03	1.78	1.42	1.78	1.42
1926–27	10	2.30	2.50	2.80	2.50	2.50	2.80	3.20	2.90
1927–28	16	1.94	2.06	2.25	2.19	2.12	2.00	2.06	1.94
1928–29	14	2.00	2.14	2.14	2.07	2.71	1.57	2.35	2.21
1929–30	23	1.95	2.04	2.22	2.12	2.09	2.22	2.30	2.09
1930–31	19	1.63	1.53	1.63	1.53	1.74	1.63	1.47	1.53
Ave. 1926–31	82	1.93	2.00	2.15	2.04	2.17	2.00	2.18	2.05

1. The marks assigned at the end of the first six-weeks period of algebra are the highest received by the city pupils and the lowest by the rural pupils over the five-year period, 1926-31.

TABLE II—COMPARISON OF FIRST AND SECOND SEMESTER ALGEBRA AVERAGES

	City			Rural		
	First Semester	Second Semester	Difference	First Semester	Second Semester	Difference
Year						
1926–27	2.59	2.29	−.30	2.50	2.90	+.40
1927–28	2.44	2.06	−.38	2.19	1.94	−.25
1928–29	2.30	2.03	−.27	2.07	2.21	+.14
1929–30	2.56	2.37	−.19	2.12	2.09	−.03
1930–31	2.43	2.12	−.31	1.53	1.53	.00
Average	2.45	2.17	−.28	2.04	2.05	+.01

2. The marks of the first six-weeks period are always higher than those of the second six-weeks period over the seven years, 1924-31, for the city pupils.

3. The marks of the entire first semester are noticeably higher than those of the second semester for the exploratory course pupils.

4. From Table 2, it is seen that city pupil grades in the second semester are less than those of the first semester by .28 whereas the average difference for the rural pupils is an increase of .01 of a grade.

5. The records of the rural pupils were too inconsistent to make a careful comparison, period by period.

6. In general, the average grade of the city, exploratory course pupil exceeded that of the rural pupil.

7. The marks of the rural pupils were higher in the third six-weeks period than at any other time in the first semester.

CONCLUSIONS

1. City pupils, who have had the exploratory mathematics of the junior high school, and who may be more intelligent than rural pupils who have not had a thorough exploratory course, decidedly surpass the latter in school marks in the first semester. This is especially true of the first twelve-weeks work. This is but natural, for the material of this period is largely a duplication of the exploratory work. This advantage begins to decrease in the third six-weeks period, when new topics are introduced.

2. The rural pupils, on the other hand, show a considerable increase in achievement beginning with the third six-weeks period. This increase, however, is marked by much fluctuation, especially in the second semester; but the average of the second semester shows an increase of one point over the first semester. On the contrary, the decrease of the city pupils in the second semester is regular.

3. The most obvious disclosure of this study is the pronounced decrease in the achievement of city pupils in the second semester. Relatively, the two groups should be about the same at the end of the first semester and the end of the second. That is true if the value of the exploratory course is to be found not only in its specific contributions but in its generalized contributions as well. Perhaps the exploratory course is not closely enough tied up with formal algebra to make a valuable generalized contribution. Perhaps there is exploration at the expense of failure to develop fundamental concepts and procedure. A definite and challenging problem is immediately presented here. There is a considerable problem of motivation involved, perhaps, as well as one of investigation of the value of the exploratory work.

4. It must be borne in mind that exploratory mathematics may have other essential values than that of preparing the way for more formal mathematics. Certainly all true junior high schools value highly other outcomes of teaching than knowledge. Development of individual differences that are desirable, interests, vocational ideas, and socializing the individual have all been claimed at one time or another as aims of the junior high school. Nevertheless, it is equally true that the "bridging" function of the junior high has also been put forth as one of its main raisons d'être. It is supposed to be an intermediate step between the elementary, unified instruction, to the secondary, departmentalized teaching. Now this facilitation of learning should result in increased learning products, as well as in less specific outcomes. That it does not lead to more satisfactory results in this school community should induce more investigation of the problem in order to achieve a more certain explanation.

SUPPLEMENTS TO GENERAL BIOLOGY.

By Sister Mary Ellen O'Hanlon,
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Probably there is less uniformity in the selection and presentation of subject matter and the placing of emphasis on the matter selected in general biology than in any other subject in the curriculum. A number of factors, more or less obvious, combine to vary the content of a given course and not the least potent among them is the instructor himself—his particular specialization, his individual preferences, as well as the laboratory equipment, library facilities, and also the locality in which his institution is situated. Fortunately, the very nature of the subject of biology is such as will offer an abundance of material and a very wide choice of content for a good course in whatever circumstances a well-trained, resourceful teacher finds himself. For this subject, with its numerous ramifications and varied applications forbids anything like a morocco-bound, compartment-tight treatment. Certainly, the cut and dried stereotyped course is always possible; but no live teacher who really loves the subject could be content for long with anything like a circumscribed, routine, dead-in-the-shell method of procedure.

On the other hand, there are certain salient facts, biological principles, theories, and hypotheses, that must be thoroughly exposed and demonstrated with good illustrative material and practical laboratory exercises if the presentation of a general course in biology is to be justified. Inasmuch as this is true, a certain amount of matter must be handled in the more regular way, that is, by following a good textbook or well prepared outline of class and laboratory exercises; but of much greater interest and, we have found, of more educational value and a much stronger stimulus to independent effort, are certain supplementary projects and activities that we have introduced from time to time during a dozen or more years of college teaching.

A few of these features which we shall discuss in the present sketch will offer little perhaps that is fundamentally new, but the technique and methods employed

together with the results and the relative merits of each may be of some practical value.

One device is the open meeting. This is an exercise which may require weeks of preparation—but preparation which is over and above that required for the regular class and laboratory exercises, although it supplements them decidedly. For an entire school day, the biology laboratories are open to visitors. The students, organized in groups each under a chairman, the latter usually chosen from the upper classes and from those whose major or minor sequence is biology, give demonstrations upon subjects which they have thoroughly mastered. The student groups are not large, usually about the same number of persons in a group as there are hours in the daily schedule. This gives each member of a group who collaborates in the preparation of an exhibit an opportunity to spend at least one hour in demonstrating her group topic to all the visitors who may be present during that hour. The spectators include besides many of the faculty members who always seem glad to cooperate by their attendance, practically the entire student body, and specially invited biology classes from other schools. In a recent meeting of this kind the students participating included a class of sixty, mostly freshmen, in general zoology and some twenty upper classmen in human physiology. Some of the topics discussed and demonstrated were: comparative anatomy of the vertebrates, embryology of amphioxus, the frog and the chick, and illustrations of the various life histories including the phenomena of metagenesis and metamorphosis. Museum material, microscopic demonstrations, models, charts, pictures, and even living specimens were included in the illustrative material.

A very good problem on the history and development of the science was worked up by a group who had previously elected a course in the history of biology. Lantern slides of the portraits of some of the outstanding contributors were used and a short biographical sketch of each contributor together with a discussion of the particular role he played in the development of the

science made a very interesting and instructive unit in that meeting.

Microscopic demonstrations are always especially attractive and are particularly valuable to students who prepare them if the latter are made responsible for the provision of the material. Living specimens of protozoa, diatoms, rotifers, the lower crustaceae, and other micro-organisms, make excellent subject matter for a problem in microscopy. Permanent mounts of almost innumerable attractive subjects are shown to good advantage with a microprojector. The number of conceivable topics which are possible if even ordinarily good equipment is available is almost inexhaustible. It is indeed difficult at times to know just what to eliminate without suppressing the enthusiasm of some students.

An open meeting in botany is conducted on the same general plan. At one of these meetings a demonstration of the complete process of slide making by the paraffine method from the killing and fixing of the material, through the embedding, microtome cutting, mounting, paraffine removal, and staining, to the finished slide, was one of the most patronized features. After this process is witnessed, the ordinary freshman seems to have greater respect for a good microscopic preparation.

The use of the camera lucida and the micrometer in making drawings of known magnification is particularly illuminating to young students and the more advanced students take a very keen delight in their superior knowledge and proceed to instruct the ignorant with great vehemence.

Next to the open meetings, of all the experiments we have tried, a biological pageant, as an extra-course activity, proved most successful. About sixty characters eminent in the making of biology from Hippocrates down to Strasburger were selected. Lantern slide portraits were secured and as many students chosen. Each student assembled biographical and other historical data on the life and works of the man she was chosen to characterize. The departments of play production and domestic art were enlisted and with their advice and as-

sistance the costuming and make up of the characters left little to be desired.

The text matter was so compiled that a reader, after introducing each character, read a short interesting sketch of his life and contributions to science while his portrait was thrown upon the screen and his living counterpart took her place upon the stage. The makers of biology were presented in chronological order and the evolution in costume from the Grecian robes to the modern type of dress made an attractive spectacle. The make up in the majority of cases was so fine as to almost startle the audience in consideration of the challenge which each actor gave the screen portrait. The pageant was given as an evening performance before a large and very appreciative audience of the parents, other relatives and friends of the students.

That the students manifest extraordinary interest in these extra-curricular activities and that they derive more than a proportional benefit for the additional effort expended, is proven in many ways. Our happy location at Rosary College gives us easy access to the Chicago museums, parks, and conservatories. These are visited regularly and such visits are of great value as every teacher of natural history is aware. Notwithstanding this truth, we have in several final examinations, required each student to discuss the one of the several extra-course activities, including these visits, which was in her estimation most instructive. The results of these tests are very much in favor of the activity in which the student participated most. Emphasis is often placed upon the particular project in which the individual made the greatest contribution, though sometimes very favorable comments are made upon the benefit derived from hearing the discussions and explanations of fellow students in making their demonstrations. The group activity, the privilege of promoting the interest of students in other departments, the opportunity for self expression in a less formal way; all of these and other factors combine to exalt the open meeting.

MATHEMATICS IN THE SCHEME OF GENERAL EDUCATION.

II. COLLECTION AND CLASSIFICATION OF DATA.

BY J. S. GEORGES,

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The educational use of mathematics was discussed in the previous article* in terms of accessibility of the fundamental and basic concepts and processes of mathematics to the educated person, and of their application in the apprehension and manipulation of all quantitative relationships. The intellectual life that an educated person is capable of living depends in a large measure upon his ability to think quantitatively. In this sense the use of mathematics is analogous to that of reading. It is generally agreed that mathematics is a special language, "a language more carefully defined and more highly abstracted than our ordinary medium of thought and expression, affording a means of thought about form and quantity, and a means of expression, more exact, compact and ready, than ordinary language." We wish to determine, if possible, in what manner, and to what extent this language is used, or ought to be used, as a mode of thought in specified fields.

We have formulated our problem specifically to determine the mathematical needs of the student of general education in terms of (a) the concepts, principles, and processes which he actually uses in his various courses, and (b) the concepts, principles, and processes which he ought to use. The determination of such needs will obviously depend upon the method of analysis employed by the investigator, and upon the activities or experiences analyzed. The method of procedure used in the determination of the mathematical needs of the student of general education will be discussed in the present article.

For the determination of factual materials the investigators in the field of curriculum-making have used both activity analysis and experience analysis. We need not go into a detailed explanation of the procedure since the vast amount of publications presenting the results of such analyses are doubtless familiar to the reader. The curriculum studies whose chief aim and concern has been the discov-

*SCHOOL SCIENCE AND MATHEMATICS, December, 1931.

ery of educational objectives on the basis of activities have used the following methods: (1) analysis of the natural activities, (2) analysis of interests, and (3) analysis of the social needs. Since activities, interests, and needs are closely associated and are dependent upon one another, these analyses have been used together to supplement one another. In their analyses the following procedures are used: (1) direct analysis of them in the classroom and outside the classroom; (2) secondary analysis of them as revealed (a) in newspapers and magazines, (b) in textbooks, and (c) in special publications; and (3) the analysis of activities, interests and needs in the opinions of competent persons and teachers.

The method of procedure used in the present study is that of text book analysis.

We have not tried to distinguish between what constitutes the activities of the educated person as separate from his experiences. We have rather endeavored to interpret the experiential contacts of the student of general education which occur directly in reading. If we succeed in identifying the concepts and principles of mathematics which provide an intelligent attitude toward, and an understanding of, the non-professional literature of the organized sciences we shall approximate closely the unique functions of mathematics in the scheme of general education.

The method of procedure is thus the analysis of the textbook materials and other reading materials in the courses, yet to be specified, of the various sciences. We have limited the field to the biological, physical, and social sciences. Perhaps the field should have been made more inclusive, but the task of analyzing even the few selected courses has been tremendous, and it is hoped that no serious sacrifice of results has been made for the sake of economy of effort and time. It is doubted if a careful analysis of courses in education, history, languages, etc., offered at the junior college level would discover essential curriculum materials in mathematics. The present investigation is not only concerned with the determination of the concepts and principles of mathematics which are, or ought to be, useful to the educated person, but also of guiding principles in the determination of the units of instruction in mathematics,

and curriculum materials for the organization of such units.

In the selection of the courses for analysis which are to represent typical experiential contacts of the student of general education we have encountered the difficulty of drawing a line of demarcation between what constitutes the experiences and activities of the specialist in a given science and those which are, or ought to be, the experiences and activities of the non-professional educated person. We are concerned with the analysis of the reading materials of the organized sciences which may be properly classified as nonprofessional literature. Perhaps the best person capable of drawing such a line of demarcation in each science is the specialist himself, for he should be able to point out the course or courses in his department which are necessary for the acquisition of an intelligent attitude toward the particular science and an understanding of its principles and doctrines in the interpretation of life in a civilized society.

Consequently the investigator requested a conference with a representative of each of the following departments at the University of Chicago: (1) Biological sciences, Botany, Zoology, and Physiology; (2) Chemistry; (3) Economics; (4) Geography; (5) Geology; (6) Physics; (7) Psychology; and (8) Sociology. The following letter of introduction was sent by Professor Morrison, then Superintendent of the Laboratory Schools of the University, to a member of each of the eight departments who was closely associated with the courses of the Junior Colleges of the University.

"We have for some time past been canvassing the mathematical learnings needed in the study of different academic subjects which fall within the field of general education—not, however, the higher and more technical courses in the several departments. Doctor J. S. Georges of the University High School group of mathematics teachers has been doing the work. His method has been to cover all the textbook material which he could find up to about the level of the end of the junior college, and second to confer personally with the instructors having in charge junior college courses.

I should appreciate it very much if you would welcome

him to a conference and direct him to the instructor or instructors in your department who would find it most convenient to confer with him in detail."

As a result of conferences with the members of the various departments the field of investigation was limited to the following courses which were offered at the University of Chicago during the years that the study was being carried on.

Biological Sciences.

1. Elementary Botany.
2. General Zoology.
3. Physiology of the Human Body.

Chemistry.

4. Elementary General Chemistry.
5. General Inorganic Chemistry.

Economics.

6. The Economic Order.
7. Intermediate Economic Theory.
8. Introduction to Accounting.

Geography.

9. Elements of Geography.
10. Economic Geography.

Geology.

11. Geologic Processes.
12. Common Minerals and Rocks.
13. Historical Geology.

Physics.

14. Elementary Physics.
15. Mechanics.
16. Electricity.
17. Heat, Sound, and Light.
18. Mechanics, Molecular Physics, and Heat.

Psychology.

19. Introductory Psychology.
20. Applied Psychology.
21. Business Psychology.

Sociology.

22. Survey of Sociology and Anthropology.
23. Introduction to the Study of Society.

During the conferences with the various instructors the purpose of the investigation was made clear, and their recommendations and opinions were carefully noted. The recommendations pertaining to the specific courses to be analyzed were faithfully followed, but their personal opinions concerning the mathematical needs of the students taking these courses, though respected by the investigator, were laid aside and did not in any way affect the findings.

The following brief list is descriptive of typical opinions expressed by specialists concerning the educational functions of mathematics in their own field.

1. In the elementary courses (biological sciences) very little mathematics is needed, but a good deal might be used.
2. In the elementary courses (geology, geography) no mathematics is used beyond finding ratios.
3. No mathematical concepts are used in the elementary courses (sociology) though some statistics needed.
4. Algebraic processes not essential to an understanding of the descriptive science (all except physics and chemistry).
5. The mathematics that an individual uses is tabulated for him, he does not need the knowledge of the concepts involved in such tables.
6. Abstract mathematics cannot be the mental equipment of all educated men. Some have not powers to acquire abstract reasoning, though they are scientific men and do well with concrete situations.
7. Algebra as taught is not of much value.
8. Students are not able to solve equations with literal coefficients (physics).
9. Statistical methods are quite useful.
10. Visualization of solids needed (geology).
11. In working with proportions students have no conception that the ratios must be between the same units (chemistry).
12. Graphic methods, and especially the interpretation of graphs, are important.
13. Students are not able to set up equations for problems (physics, chemistry, economics).
14 Ability needed to apply general formulas to special cases.
15. Finding per cents (economics, geology, geography).
16. Mathematics of a general nature might be useful.
17. Functionality is of great importance to the student of science.
18. Mastery of algebraic processes essential (physics).

With the exception of physics, the opinions expressed by the specialists in the various sciences stressed two points. First, the elementary courses are of a descriptive character, and so little or no mathematics is needed to comprehend the scientific materials of a given text. Second, with the exception of Psychology, all stressed the fact that in the pursuit of courses on the graduate level the student needs advanced mathematics, calculus, differential equations, definite integrals, elliptic functions (physics), and calculus of variations (economics). Now it is quite obvious that somehow the gap existing between the mathematical needs of the student of elementary sciences and those of the future specialist must be bridged over. According to the expressed opinions of the specialists in the various sciences mathematical concepts and processes are not utilized in the elementary courses, and are avoided if possible. In his ele-

mentary courses, say in sociology and anthropology, the student of general education does not come in contact with mathematics, sees no necessity for taking more mathematics and is not encouraged to do so. We will assume that the student decides to specialize in the subject. His specialization continues and he finds himself in a few years seriously engaged in research, but he also finds, to his utter dismay and discouragement, that he needs the services of mathematics of the highest type. The solution of the problem is beyond the scope of our investigation, we merely mention it as another aspect of the functions of mathematics in education, namely, specialized education.

The typical courses having been designated and the source of materials such as the textbooks, lectures, and laboratory manuals, specified, the investigator then set about analyzing this material to seek the necessary factual information. Each topic or sub-topic was carefully studied and analyzed, keeping in mind the important queries of the investigation, namely, "What mathematical concepts, principles, and processes have been used in the presentation and development of the topic, and what mathematical concepts, principles, or processes might have been used to advantage by the writer of the textbook?" The mathematical information secured from the analysis of each topic was recorded on separate cards. These cards were then numbered and filed away for future study. Table I presents the distribution of the cards relative to the different departments.

TABLE I. DISTRIBUTION OF THE CARDS.

Department	Number	Per cent
Biology	98	2.6
Chemistry	702	18.7
Economics	805	21.4
Geology-geography	314	8.3
Physics	918	24.4
Psychology	640	16.9
Sociology	288	7.7
Total	3765	100.0

Each card contains a definite situation and presents a single mathematical idea in connection with that situation. Such a simple card is ready for the next step which is the classification of the cards. An example of a simple card is reproduced below.

CARD No. 1381.

Graph showing the influence of poor illumination upon output. Output for ordinate, time for abscissa.
Mathematical principle: Continuous graph.

However, most of the cards are complex cards, that is, they contain several mathematical ideas in connection with the situation which they describe. These complex cards give rise to several other cards, the latter being simple cards. The cards exhibited by Table I are all simple cards. An example of a complex card is given below.

CARD No. 185.

Determining the atomic weight.

$$\frac{\text{The weight of 1 atom of E}}{\text{The weight of 1 mol. of O}} = \frac{A/(2.7\text{x}10^{22})}{1.429/(2.7\text{x}10^{22})}$$

Hence the weight of 1 atom of E = Ax22.4 units.
Mathematical principles:

1. Algebraic representation.
2. Exponential representation, large numbers.
3. Ratio.
4. Proportion.
5. Reduction, complex fractions.
6. Substitution.
7. Evaluation.
8. Solution of equation $\frac{X}{32} = \frac{A}{1.429}$
9. Scientific notation.

In the classified list the above card has been replaced by nine other cards, each illustrating one of the nine mathematical ideas in connection with the determination of atomic weights.

With the complete analysis and exhaustion of the source of materials the preliminary stage of the investigation is completed. The next stage is the classification of the cards according to comprehensive principles under each of which many principles from the preliminary survey group together. The identification of these principles follows directly from the information contained on the separate cards. The preliminary survey reveals a number of mathematical ideas. A folder is provided for each of these ideas, and the cards are then distributed among the folders. A list of the folders is presented below, their analysis and the interpretation of their contents will be the theme of the third article of this series.

LIST OF THE FOLDERS.

1. Algebraic expressions, symbolic representation.
2. Algebraically stated relationships, formulas.

3. Algebraic processes, operations, and manipulations.
4. Analysis.
5. Angles, relations, mensuration, construction.
6. Areas, surface relations, plane figures.
7. Approximations, methods, approximate numbers.
8. Binomial theorem, applications.
9. Combinations, permutations.
10. Camparisons, ratios, differences.
11. Complex numbers.
12. Computations, short methods.
13. Constants, of variation.
14. Curves, curvature, radius of curvature.
15. Directed numbers, vectors.
16. Direct variation, linear, quadratic.
17. Evaluation.
18. Exponents, exponential representation.
19. Fractions, algebraic, operations, simplifications.
20. Functionality.
21. Generalizations, laws from special cases.
22. Geometric relationships, theorems.
23. Graphs, graphic representation.
24. Groups, grouping.
25. Inverse variation, hyperbolic law.
26. Inequalities.
27. Infinity.
28. Invariance.
29. Irrationals, operations, equations.
30. Joint variations, number of variables, evaluations, reductions.
31. Limits.
32. Linear function.
33. Linear equations, systems.
34. Logarithmic functions, logarithms.
35. Maxima, minima.
36. Measurement, direct, indirect.
37. Periodicity, periodic functions.
38. Probability.
39. Projections.
40. Plane figures, mensuration, relations, construction.
41. Power functions.
42. Progressions, arithmetic, geometric.
43. Proportions, proportional representation.
44. Quadratic functions.
45. Quadratic equations, systems.
46. Range.
47. Rate, slope.
48. Ratio, per cent.
49. Series, finite, infinite.
50. Similarity.
51. Scientific notation.
52. Special cases.
53. Solids.
54. Statistical methods.
55. Subscripts.
56. Summation.
57. Symmetry.
58. Tabular representation.
59. Transformations, simplifications of formulas.
60. Trigonometric functions.
61. Variables, variation.
62. Volume relations.
63. Miscellaneous, unclassified.

SCIENCE LIBRARY FOR ELEMENTARY SCHOOLS.

BY ELLIS C. PERSING,
School of Education, Western Reserve University, Cleveland, Ohio.

Books are essential in the quest for scientific knowledge even though apparatus and specimens are available for study. There are at least necessary to supplement our activities with the concrete materials. Without adequate reference books both the acquisition of facts and the understanding of principles are considerably delayed. Books need not replace the experience with actual science material, but rather to guide and stimulate one in the pursuit of scientific thinking. They are guide posts that make it possible for us to find ourselves on the highways and byways of science.

For our elementary school science libraries we must first discard the books which are out of date. Progress in science research proceeds so rapidly that books in some field of science are obsolete in a few years. New books which help us to keep up with science are constantly coming from the publishers. We must therefore find these books which are adapted to our needs and add them to our shelves.

Children demand books that give the latest development in such fields as aviation, exploration, and inventions. These books must give accurate information in a style which can be understood by groups of grades such as the primary (1, 2, 3, grades), intermediate (4, 5 and 6), and Junior High School (7, 8 and 9).

Recent revisions in the curriculum for the elementary schools to include the teaching of science are largely responsible for the new demands by teachers and pupils for suitable reference books. The inclusion of such units as *transportation* naturally stimulate the pupils to investigate the steam engine, the electric locomotive, and numerous other devices.

The books listed have been examined and in some instances the reactions of both children and teachers have been obtained. The titles are arranged under the main headings which are most commonly used in the elementary school. All possible sources were searched for new

books, but only those which meet a definite need have been included. In addition books which were considered essential were listed even though the copyright date was several years previous.

Every effort was made to exclude books which were found to have inaccurate statements of factual material. Those which did not directly or in some way supplement a main heading were not mentioned.

The following is the list of science books:

ANIMAL LIFE.

Stories.

Bailey, Vernon—*Animal Life of Yellowstone National Park,* Thomas, 1930 .... $4.00
Factual material prepared by a biologist and beautifully illustrated.

DuPuy, William Atherton—*Our Animal Friends and Foes,* Winston, 1925 .... .80
Supplementary Reader—twenty animal stories.

Eipper, Paul—*Animals Looking at You,* Viking, 1929 .... 3.00
Animal stories for old and young.

Anonymous—*Animal World,* Gabriel, 1914 .... .60
Interesting animal pictures.

Burgess, Thornton W.—*Billy Mink,* Little, 1924 .... 1.50
Fascinating animal stories for children.

Burgess, Thornton W.—*Billy Mink,* Little, 1919 .... 1.50
Information in story form. One of the *Smiling Pool Series.*

Burgess, Thornton W.—*The Burgess Animal Book for Children,* Little, 1920 .... 3.00
Forty stories for children.

Burgess, Thornton W.—*The Burgess Seashore Book for Children,* Little, 1929 .... 3.00
Beautifully illustrated stories of shore life.

Burgess, Thornton W.—*Jerry Muskrat at Home,* Little, 1926 .... 1.50
Stories presenting scientific facts about this mammal.

Burgess, Thornton W.—*Lightfoot the Deer,* Little, 1923 .... 1.50
Another of the Green Forest Series.

Burgess, Thornton W.—*Longlegs the Heron,* Little, 1916 .... 1.75
A fascinating story for elementarry school level.

Burgess, Thornton W.—*Mother West Wind's Animal Friends,* Little, 1912 .... 1.00
Animal stories for young children.

Butler, Eva L.—*Along the Shore,* Day, 1930 .... 1.25
A good Handbook for children.

Carhart, A. H. and Young, S. P.—*The Last Stand of the Pack,* Sears, 1929 .... 2.50
An animal tale of the western plains.

Patch, Edith M.—*Holiday Pond,* Macmillan, 1929 .... 2.00
Stories of pond life for primary grades.

Seton, Ernest T.—*Animals Worth Knowing,* Doubleday, 1925
Factual material for teachers and pupils.

Tracks.

Brunner, Josef—*Tracks and Tracking,* Macmillan, 1925 .... 1.00
Useful for pupils and teacher.

Rossell, Leonard—*Tracks and Trails,* Macmillan, 1928 .... 1.25
Twenty-one animal stories beautifully illustrated.

Pets.

Browne, Carmen—*My Book of Pets*, Volland, 1923 .... .50
A good picture book for primary grades.

Comstock, Anna Botsford—*The Pet Book*, Comstock, 1914 .... 3.50
A comprehensive handbook.

Zirbes and Keliher—*The Book of Pets*, Keystone View Co., 1928 .76
Supplementary reader for primary grades.

AQUARIUM.

Eggeling, Otto & Ehrenberg, F.—*The Freshwater Aquarium and its Inhabitants*, Holt, 1912
A most useful reference for pupils and teachers.

Page, Charles N.—*Aquaria*, Author .... .25
Useful booklet.

AVIATION.

Allen, Elmer L.—*Model Airplanes*, Stokes, 1928 .... 3.50
How to build and fly models. For intermediate and junior high school level.

Barry and Hanna—*Wonder Flights of Long Ago*, Appleton, 1930 .... 1.00
Interesting supplementary reader for intermediate grades.

Collins, A. Frederick—*Aviation and All About It*, Appleton, 1929 .... 2.00
A good reference book for the use of teachers and upper grade pupils.

Collins, Francis A.—*The Boy's Book of Model Aeroplanes*, Century, 1921 .... 2.00
A guide for construction of model airplanes.

Fraser, Chelsea—*Heroes of the Air*, Crowell, 1928 .... 2.00
Thrilling stories of flight from Wright Brothers to the present time.

Green, Fitzhugh—*Dick Byrd—Air Explorer*, Putnam, 1928 .... 1.75
A fascinating story of Byrd's explorations.

Hodgins and Magoun—*Sky High*, Little, 1930 .... 2.50
Fascinating story of the history of aviation.

Holland, Rupert S.—*Historic Airships*, Macrae, 1928 .... 4.00
History and development of aviation, fully illustrated.

Jones, Paul—*An Alphabet of Aviation*, Macrae, 1928 .... 2.00
Beautifully illustrated. Answers children's questions about airplanes and balloons.

Klemin, Alexander—*First Book in Aviation*, Coward-McCann, 1928 .... 2.50
Fourteen chapters on how to fly. In Story form.

LePage and Warner—*The ABC of Flight*, Wiley, 1928 .... 1.50
Principles of aviation and how they operate.

McMahon, John R.—*The Wright Brothers*, Little, 1930 .... 2.50
A complete story of the experiences of two men in the development of aviation.

Page, Victor W.—*Everybody's Aviation Guide*, Henley, 1928.......... 2.00
Six hundred questions and answers on design, construction, and operation of aircraft.

Page, Victor W.—*The ABC of Aviation*, Henley, 1928.......... 1.00
A good handbook for pupils and teachers.

Romer and Romer—*Sky Travel*, Rand, 1929.......... 1.48
Supplementary reader for intermediate grades.

Rolt-Wheeler, Francis—*The Boy With the U. S. Aviators*, Lothrop, 1929 .... 1.75
A thrilling story of flight.

Studley, Barrett—*How to Fly*, Macmillan, 1929.......... 3.00
Directions on how to go about learning to fly.

Williams, Archibald—*Conquering the Air*, Nelson, 1930 .... 2.00
A thrilling story of aviation.

BIRDS.

Burgess, Thornton W.—*The Burgess Bird Book for Children*, Little, 1919 .... 3.00
Forty-five stories for primary grades.

Burgess, Thornton W.—*Longlegs, The Heron*, Little, 1927 .... 1.75
A whole book on the story of the heron.

Chapman, Frank M.—*Our Winter Birds*, Appleton, 1918 .... 1.50
How to know, enjoy, and care for the winter birds.

Chapman, Frank M.—*The Travels of Birds*, Appleton, 1916 .... .76
How and why the birds migrate.

Chapman, Frank M.—*What Bird Is That?*, Appleton, 1920 .... 1.50
Most helpful for identification.

DePuy, William A.—*Our Bird Friends and Foes*, Winston, 1925 .80
A supplementary reader for intermediate grades.

Hyde, Mary K—*Children, Meet the Birds*, Stratford, 1929 .... 1.50
Combines facts, fancy, and fairy fiction.

Mosely, Edwin Lincoln—*Trees, Stars, and Birds*, World, 1919 .... 1.80
Good reference for pupils and teachers.

EARTH.

Hillyer, V. M.—*A Child's Geography of the World*, Century, 1929 3.50
Fascinating stories of the world's lands and peoples.

Tillotson and Taylor—*Grand Canyon Country*, Stanford, 1929 .... 2.00
The wonders of a national playland.

ELECTRICITY.

Bliss, Howard H.—*Elements of Applied Electricity*, Holt, 1925 .... 1.96
Fundamentals and application of electricity.

Collins, A. Frederick—*The Amateur Electrician's Handbook*, Crowell, 1924 .... 2.00
Experiments for intermediate and junior high levels.

Keelor, Katherine—*Working With Elecricity*, Macmillan, 1929 .. 1.75
The story of electricity for primary grades.

Lacey, Ida Belle—*Light—Then and Now*, Macmillan, 1930 .... .88
The story of the progress of lighting for primary grades.

Parker, Bertha M.—*The Book of Electricity*, Houghton, 1928 .... .92
A reader or text for intermediate grades.

Sloane, T. O'Conor—*Arithmetic of Electricity*, Henley, 1930 .... 1.50
The arithmetical processes rather than the formula are emphasized.

EXPERIMENTS.

Collins, A. Frederick—*Boy's Book of Experiments*, Crowell, 1927 2.00
A book of experiments for children and adults.

Collins, A. Frederick—*Experimental Chemistry*, Appleton, 1930 2.00
Simple and spectacular experiments.

Gordon, Bertha F.—*Prove It Yourself*, Owen, 1928 .... 1.50
A book of experiments in elementary science.

FARMS.

Conway-Kauffman-Lancelot—*Nature in Agriculture*, Webb, 1928 1.20
Topics for a course in agriculture for intermediate and junior high level.

GARDENING.

Brewster, Kate L.—*The Little Garden for Little Money*, Little, 1924 .... 1.75
A practical guide "Fool-proof."

Giles, Dorothy—*The Little Kitchen Garden,* Little, 1926 .... 1.75
Plans for making use of the waste soil around the small house.

King, Francis—*The Little Garden,* Little, 1926 .... 1.75
A guide for the beginner.

Wodell, Helen Page—*Beginning to Garden,* Macmillan, 1928 .... 1.75
Fundamentals of tilling and planting for young people.

INSECTS.

Rowe, H. G.—*Starting Right With Bees,* Root, 1922 .... .75
Essentials for beginners in beekeeping.

DePuy, William Atherton—*Our Insect Friends and Foes,* Winston, 1925 .... .80
Supplementary reader with twenty-three insect stories.

Johns and Averill—*Moths and Butterflies,* Owen, 1929 .... .72
Factual reading material for young children.

Weed, Clarence M.—*Insect Ways,* Appleton, 1930 .... 2.50
A series of stories on insect life for the upper grades.

INVENTIONS.

Bachman, Frank P.—*Great Inventors and Their Inventions,* American Book, 1918 .... .80
Twelve great inventions are described.

Bridges, T. C.—*Young Folk's Book of Invention,* Little, 1927 .... 2.00
Achievements of great inventors. Secrets of nature realized in useful devices.

Darrow, Floyd L.—*Builders of Empire,* Longmans, 1930 .... 2.50
Interesting stories of the lives of leaders in the fields of science.

Forman, S. E.—*Stories of Useful Inventions,* Century, 1911 .... .90
History and development of useful inventions.

Darrow, Floyd L.—*The Boy's Own Book of Inventions,* Macmillan, 1918 .... 2.00
The story of some epoch-making inventions with home laboratory experiments illustrating principles involved.

MAGIC.

Blackstone, Harry—*Secrets of Magic,* Sully, 1929 .... 2.00
Magic for the beginner and the amateur.

MAMMALS.

Burroughs, John—*Squirrels and Other Fur-Bearers,* Houghton .. .92
Information about sixteen common mammals.

Carr, William H.—*The Stir of Nature,* Oxford, 1930 .... 2.50
Stories of wild folk friends on intermediate level.

Johnson, Martin—*Lion,* Putnam's, 1929 .... 5.00
The thrilling adventures of Martin Johnson and Osa, his wife, studying lions in Africa.

Moseley, Edwin Lincoln—*Our Wild Animals,* Appleton, 1927 .... 1.20
Contains accurate information about twenty-nine animals.

Newell, David—*American Animals,* Volland, 1929 .... 1.00
Entertaining rhymes with true information about animals.

Seton, Ernest T.—*Wild Animal Ways,* Houghton, 1916 .... .96
Interesting supplementary reading material.

Warren, Deward R.—*The Beaver,* Williams, 1927 .... 3.00
Full and accurate account of the habits and life of the beaver.

OUT-OF-DOORS.

Camps.

Jessup, Elon—*The Boys' Book of Camp Life,* Dutton, 1928 .... 2.50
Information of the different phases of camping.

Kephart, Horace—*Camping and Woodcraft*, Macmillan, 1924...... 2.50
A manual for the hiker and the woodsman.

Seton, Ernest Thompson—*The Book of Woodcraft*, Doubleday, 1927 .... 2.00
The principles of woodcraft and how to use them.

Trails.

Davenport, Eugene—*Vacation on the Trail*, Macmillan, 1923........ 1.50
The author's personal experience on mountain trails. Complete directions for outfitting expeditions.

Lange, Dietrich—*Nature Trails*, Appleton, 1927........ 2.00
Sketches of wild life—supplementary reader for upper grades.

Scoville, Samuel Jr.—*The Out-of-Doors Club*, Harper, 1927........ 1.50
The story of five children and the parents.

PHYSICAL SCIENCE.

Stories.

McGowan, Ellen B.—*Soap Bubbles*, Macmillan, 1929........ .80
Information in story form—supplementary reading for upper grades.

Thomson, Jay Earle—*Aviation Stories*, Longmans, 1929........ 1.25
True aviation stories of adventure for upper grade level.

Transportation.

Fox, Florence C.—*How the World Rides*, Scribner, 1929........ .88
Stories of travel on intermediate grade level.

Hader, Berta & Elmer—*The Story of Transportation*, Macmillan 1928 .... 2.00

Holland, Rupert S.—*Historic Railroads*, Macrae, 1927........ 4.00
A history of railroads beautifully illustrated.

Van Metre, T. W.—*Trains, Track, and Travel*, Simmons-Boardman, 1926 .... 3.50
History and development of railway, locomotives and equipment on upper grade level.

PLANTS.

Cultivated Flowers.

Rockwell, F. F.—*The Book of Bulbs*, Macmillan, 1927........ 3.00
Flowering bulbs—spring, summer and autumn—for upper grade classes.

Wild Flowers.

Jones, James E.—*Some Familiar Wild Flowers*, Macmillan, 1930 .... 1.50
Handy pocket manual for identification of wild flowers.

Burgess, Thornton W.—*The Burgess Flower Book for Children*, Little, 1923 .... 3.00
Stories about flower life for young children.

Houghton, Arthur D.—*The Cactus Book*, Macmillan, 1930........ 2.25
Care and propogation of cacti for upper grades.

Mathews, Schuyler F.—*The Book of Wild Flowers*, Putnam, 1923 .... 3.00
Information in narrative form. Beautifully illustrated.

Reed, Chester A.—*Flower Guide*, Doubleday, 1922........ 1.50
A handy pocket guide.

General.

Kenly, Julie C.—*Green Magic*, Appleton, 1930........ .92
Story about plants for upper grades.

MacDougal, D. T.—*The Green Leaf*, Appleton, 1930........ 3.00
Whole book is on the miraculous performance of the green leaf.

Poetry.

Grover, Edwin O.—*The Nature Lover's Knapsack,* Crowell, 1927 2.50
More than two hundred and fifty poems for nature lovers.
Newell, David—*American Animals,* Volland, 1929 .... 1.00
Entertaining rhymes with true information about animals.

Protecting Our Wild Life.

Fairbanks, Harold W.—*Conservation Reader,* World, 1925 .... 1.20
Supplementary reader for upper grades.
Harris, Garrard—*Elements of Conservation,* Johnson Publishing 1924 .... .80
Factual reading material for intermediate grades.
Rolfe, Mary A.—*Our National Parks,* Sanborn, 1927:
Book I 1.00
Book II 1.00
National Parks are described in story form. Useful information on elementary school level.

Rocks and Soils.

Wheeler, Ida W.—*Playing With Clay,* Macmillan, 1927 .... 2.00
A book of children's stories of pottery and sculpture with directions for making several articles of clay.

Science Readers and Texts.

Albright and Hall—*Nature Stories for Children,* Mentzer, 1927:
Book I .... .72
Book II .... .72
Autumn .... .72
Spring .... .72
For primary grades.
Caldwell and Meier—*Open Doors to Science,* Ginn, 1926 .... .75
For upper grades.
Fairbanks, Harold W.—*Conservation Reader,* World, 1925 .... 1.20
For upper grades.
Gale, Elizabeth—*Circus Animals,* Rand, 1924 .... .85
For primary grades.
Gehrs, John H.—*Agricultural Nature Study,* American Book, 1929:
Book I .... .80
Book II .... .80
For intermediate grades.
Meyer, Zoe—*Sunshine Farm,* Little, 1927 .... 1.00
Supplementary reading for primary grades.
Meyer, Zoe—*Under the Maple Tree,* Little, 1928 .... .70
Supplementary reading for primary grades.
Nida and Nida—*Science Readers,* Heath:
Book I, 1928 .... .80
Book II, 1928 .... .88
Book III, 1926 .... .88
Book IV, 1926 .... .88
Book V, 1926 .... .88
Book VI, 1926 .... .88
Patch, Edith M.—*First Lessons in Nature Study,* Macmillan, 1926 .... 1.12
Factual material about plants and animals for primary grades.
Payne, Barrows, Schmerber—*Elementary Science Readers,* Sanborn, 1927:
Book I .... .72
Book II .... .72
Book III .... .76

Book IV .76
Pershing & Peeples—*Elementary Science by Grades*, Appleton:
Book I, 1930 .72
Book II, 1928 .72
Book III, 1928 .80
Pershing & Wildman—*Elementary Science by Grades*, Appleton, 1929, Book IV .92
Pershing & Thiele—*Elementary Science by Grades*, Appleton, 1930, Book V .96
Pershing & Hollinger—*Elementary Science by Grades*, Appleton, 1930, Book VI 1.00
Trafton, Gilbert H.—*Nature Study and Science for Intermediate Grades*, Macmillan, 1927 1.20
Troxell, Eleanor & Dunn, Fannie—*Mother Nature Series*, Row, Peterson and Co., 1928:
Baby Animals .68
By the Roadside .76
In Field and Forest .80
Zirbes, L. & Wesley M.—*The Story of Milk*, Keystone View Co., 1926 .68
Factual material for lower grades.
Zirbes, L. & Wesley M.—*Workers*, Keystone View Co., 1928 .58
Supplementary reading for primary grades.

SHIPS

Cartwright, Charles E.—*The Boys' Book of Ships*, Dutton, 1925 2.00
Development of the ship from early times to the present.
Curtis, Nell C.—*Boats*, Rand, 1927 .80
Factual material about boats and activities of children on third grade level.
Leitch, Albert C.—*Miniature Boat Building*, Henley, 1928 3.00
Directions for building model racing, sail, and power boats.
McCann, E. Armitage—*Ship Model Making*, Henley, 1926:
Vol. I 2.50
Directions for making model of a Spanish galleon and Barbary Pirate Ships.
Vol. II 2.50
Directions for making model of a clipper ship.
Wright, Lula E.—*The Magic Boat*, Ginn, 1927 .80
Supplementary reading for primary grades.

SKY STUDIES.

Mosely, Edwin L.—*Trees, Stars and Birds*, World, 1919 1.80
Factual material for upper grades.
Proctor, Mary—*The Young Folk's Book of the Heavens*, Little, 1924 2.00
Information about the stars in conversational style for intermediate grades.
Williamson, Julia—*The Stars Through Magic Casements*, Appleton, 1930 2.00
Stories about the great constellations on the elementary school level.

SOME THINGS TO DO.

Bullivant, Cecil H.—*Every Boy's Book of Hobbies*, Nelson, 1912 2.00
The workshop at home, indoor hobbies, collecting, outdoor hobbies, and keeping of pets are described.
Dixon and Hartwell—*The Fun-Craft Book*, Rand, 1929 1.00
One of a series of Activities books.
Dixon and Hartwell—*The Make-It Book*, Rand, 1928 1.00
Directions for boys and girls on how to make things.

Fraser, Chelsea—*The Boy's Busy Book*, Crowell, 1927 .... 2.50
How and what to do for boys.

Hall, A. Neely—*Big Book of Boy's Hobbies*, Lothrop, 1927 .... 2.50
A collection of things boys will like to make.
Intermediate grade level.

Hall, A. Neely—*Making Things With Tools*, Rand, 1928 .... 1.00
Interesting activities are suggested for boys.

Popular Mechanics Press—*The Boy Mechanic*, Popular Mechanics Press:
Book I, 1929 .... 2.00
Book II, 1915 .... 2.00
Book III, 1919 .... 2.00
Book IV, 1925 .... 2.00

Hundreds of articles for boys and girls to make.

Showalter, Hazel F.—*The Box Book*, Macmillan, 1929 .... 1.75
A fascinating list of things to make on the primary and intermediate grade level.

Williams, Archibald—*Things Worth Making*, Nelson, 1920 .... 1.72
Complete directions for both useful articles and play devices.

SPIDERS.

Patterson, Alice—*The Spinner Family*, McClurg, 1927 .... 1.75
Simple accurate story of the habits and characteristics of of some of our common spiders.

SUPPLEMENTARY READING.

Edwards, Charles L.—*Jose*, Hesperian Press, 1930 .... .25
Edwards, Charles L.—*The Search for Beauty*, Hesperian Press, 1930 .... .25
Horn-Cutright-Horn—*First Lessons in Learning to Study*, Ginn, 1926 .... .48
Horn & Schields—*Learn to Study Readers*, Ginn:
Book I, 1924 .... .48
Book II, 1924 .... .54
Book III, 1925 .... .60
Book IV, 1926 .... .66
Book V, 1926 .... .72

Verrill, Addison E.—*True Nature Stories, Badger*, Gorham Press, 1929 .... 2.00
Factual material for intermediate grades and teachers use.

White & Hanthorn—*Boys and Girls at School*, American Book, 1930 .... .40
White & Hanthorn—*Boys and Girls at Work and Play*, American Book, 1930 .... .60
White & Hanthorn—*Stories of Animals and Other Stories*, American Book, 1930 .... .80

TEACHERS' REFERENCES.

Animals.

Alexander, W. B.—*Birds of the Ocean*, Putnam, 1928 .... 3.50
A handbook for voyagers.

Anthony, H. E.—*Field Book of North American Mammals*, Putnam, 1928 .... 5.00
Handbook for identification and essential facts.

Henderson, J.—*Practical Value of Birds*, Macmillan, 1927 .... 2.50
Very complete source book.

Koppanyi, Theodore—*The Conquest of Life*, Appleton, 1930 .... 2.00
Fundamental concepts of biology presented for the layman.

Mathews, Schuyler F.—*Field Book of Wild Birds and Their Music*, Putnam, 1921 .... 3.50
A manual for teachers and naturalists.

Needham, James G.—*Elementary Lessons on Insects*, Thomas, 1928 .... 2.00
An outline for a brief course in entomology.

Gardening.

Rockwell, Frederick F.—*Around the Year in the Garden*, Macmillan, 1926 .... 2.50
A seasonable guide. Factual material for teachers' use.

Volz, Emil C.—*Home Flower-Growing*, Macmillan, 1929 .... 3.50
Principles and practices for indoors and outdoors. Background for teachers.

Plants.

Clute, Willard N.—*Our Ferns in Their Haunts*, Stokes, 1901 .... 4.50
Illustrated key to the common ferns.

Downing, Elliot R.—*Our Living World*, University of Chicago Press, 1919 .... 2.00
A source of information for the teacher.

Durand, Herbert—*Field Book of Common Ferns*, Putnam, 1928 .... 2.50
Useful for identification of the fifty fern species.

Durand, Herbert—*Wild Flowers and Ferns in Their Homes and in Our Gardens*, Putnam, 1925 .... 3.50
More than 150 illustrations, 23 of which are in color.

Fairchild, David—*Exploring for Plants*, Macmillan, 1930 .... 5.00
A narrative of the adventure of scientists in the islands of the East Indies.

Hamblin, Stephen F.—*American Rock Gardens*, Judd, 1929 .... 1.25
How to make and operate a rock garden.

McCormick, Thomas C.—*Agriculture for Rural Teachers*, Macmillan, 1929 .... 1.80
A volume on the teaching of agriculture.

McKenny, Margaret—*Muchrooms of Field and Wood*, Day, 1929 .... 2.00
A guide for the recognition of mushrooms. Prepared especially for young people.

Pack, A. N. & Palmer, E. L.—*The Nature Almanac*, American Nature Association, 1930 .... 1.00
A handbook of Nature Education.

Palmer, E. L.—*Field Book of Nature-Study*, Slingerland-Comstock Co., ... 2.50
A guide for identification of mammals, birds, game, fishes, amphibia, reptiles, galls, insects, plants.

Parsons, Frances—*How to Know the Ferns*, Scribner, 1924 .... 2.50
A key to the common ferns.

Roberts and Rehmann—*American Plants for American Gardens*, Macmillan, 1929 .... 2.00
A handbook for landscaping based on plant ecology.

Rockwell, F. F.—*The Book of Bulbs*, Macmillan, 1927 .... 3.00
Flowering bulbs—spring, summer and autumn—for upper grade classes.

Thomas, William S.—*Field Book of Common Gilled Mushrooms*, Putnam, 1928 .... 3.50
Key to identification of 128 species of gilled mushrooms in the field.

Ullrich, Fred T.—*Our Farm World*, Longmans, 1929 .... 3.00
A textbook for teachers in the upper grades.

Physical Science.

Abbot, Charles G.—*The Sun*, Appleton, 1929 .... 3.50
A scientific, up-to-date work on the teachers' and older pupils' level.

Chamberlin & Salisbury—*College Text-Book of Geology*, Holt, 1930 .... 5.50
A college text-book—excellent reference for teachers in elementary school.

Chant, Clarence A.—*Our Wonderful Universe*, World 1.52
Interesting factual material on intermediate grade level.

Downing, Elliot R.—*Our Physical World*, University of Chicago Press, 1924 .... 2.00
Factual material for teachers in elementary school.

Elm, Ienor E.—*Navigation by Dead Reckoning*, McKay, 1928 .... 2.00
A practical book for instruction. Background for teachers.

Wendt & Smith—*Matter and Energy*, Blakiston's Son & Co., 1930, Vol. I 1.50
Subject matter in fields of chemistry and physics. Background for teachers.

General.

Ashbrook, Frank G.—*Fur-Farming for Profit*, Macmillan, 1928 4.00
Essential facts on fur-farming in North America.

Chapman, Frank M.—*My Tropical Air Castle*, Appleton, 1929 5.00
The story of a scientists adventures telling about the romance of tropical wild life.

Lutz, Frank E.—*Field Book of Insects*, Putnam, 1921 .... 3.50
Handbook for identification of insects fully illustrated.

Morgan, Ann H.—*Field Book of Ponds and Streams*, Putnam, 1930 .... 3.50
A handbook of the life in pond and stream. Fully illustrated.

Needham, James G.—*Elementary Lessons on Insects*, Thomas, 1928 .... 2.00
A brief introductory course in entomology.

Olcott, William T.—*Field Book of the Skies*, Putnam, 1929 .... 3.50
Handy practical guide to study stars with naked eye, field glass, and three-inch telescope. Helpful to teachers and older pupils in elementary school.

TOYS.

Hall, A. Neely—*Home-made Toys for Girls and Boys*, Lothrop, 1915 .... 2.00
How children can make toys they like.

Morgan, Alfred P.—*Boys' Home Book of Science and Construction*, Lothrop, 1921 .... 2.50
Plans, fully illustrated for making a variety of mechanical devices.

Polkinghorne, R. K. & M. I.—*Toy-Making in School and Home*, Stokes 3.00
Directions for making toys of simple materials for ages three to twelve.

TREES

Cheyney, E. G.—*What Tree Is That?*, Appleton, 1927 .... 2.00
A key for identification and essential facts about each tree.

Fry & White—*Big Trees*, Stanford University Press, 1930 .... 2.00
The story of the largest and oldest living things.

Moseley, Edwin L.—*Trees, Stars, and Birds*, World, 1919 .... 1.80
Essential facts about trees.

Illick, Joseph S.—*Common Trees of Ohio*, American Tree Association, 1927
A guide for the identification of trees—Gratis.

Rohan, Ben. J.—*Our Forests*, Nelson Publishing Co. (C. C.) 1929 .... 1.00
Information to help solve the forest problems.

Hall, Charles A.—*Trees*, Black, 1930 .... 1.00
Hall, Charles A.—*Trees*, Black, 1930 .... 1.00
Species native to Britain are described.

Evergreens.

Schrepfer, Frank A.—*Hardy Evergreens*, Judd, 1928 .... 1.25
Handbook on the planting growth and management of hardy evergreens.

Rockwell, F. F.—*Evergreens*, Macmillan, 1928 .... 1.00
Handbook on evergreens for the home-owner.

PUBLISHERS AND THEIR ADDRESSES (BRIEFLY AND IN FULL)

American Book: American Book Co., 300 Pike St., Cincinnati, Ohio
American Nature Association, Washington, D. C.
American Tree Association, Washington, D. C.
Appleton: D. Appleton & Co., 35 W. 32nd St., New York, New York
Badger: Richard G. Badger, The Gorham Press, 100 Charles St., Boston, Mass.
Black, A. & C., The Macmillan Co., 60 5th Ave., N. Y. C.
Blakiston: P. Blakiston's Sons & Co., 1012 Walnut St., Philadelphia
Century: The Century Co., 353 4th Ave., New York
Comstock: Comstock Publishing Co., 124 Roberts Place, Ithaca, New York
Coward-McCann, Inc., 425 4th Ave., New York
Crowell: Thomas Y. Crowell Co., 393 4th Ave., New York
Day: John Day Co., Inc., 25 W. 45th St., New York City
Doubleday: Doubleday, Page & Co., Garden City, New York
Dutton: E. P. Dutton & Co., 286 4th Ave, New York
Gabriel: Samuel Gabriel Sons & Co., 76 5th Ave., New York
Ginn: Ginn & Co., 15 Ashburton Place, Boston, Mass.
Harper: Harper & Brothers, 49 E. 33rd St., New York City
Heath: D. C. Heath & Co., 50 Beacon St., Boston, Mass.
Henley: Norman W. Henley Publishing Co., 2 W. 45th St., New York
Holt: Henry Holt & Co., 2626 Prairie Ave., Chicago
Houghton: Houghton Mifflin Co., 2 Park St., Boston, Mass.
Johnson Publishing: Johnson Publishing Co., 11th and Corn St., Richmond, Va.
Judd: Orange Judd Publishing Co., 15 E. 26th St., New York
Keystone View Co., Meadville, Pa.
Little: Little, Brown & Co., 34 Beacon St., Boston, Mass.
Longmans: Longmans, Green & Co., 56 5th Ave., New York City
Lothrop: Lothrop, Lee & Shepard Co., 275 Congress St., Boston, Mass.
Macmillan: The Macmillan Co., 60 5th Ave., New York City
Macrae: Macrae Smith Co., 1712 Ludlow St., Philadelphia
McClurg: A. C. McClurg & Co., 329 E. Ontario St., Chicago
McKay: David McKay, 604 S. Washington Sq., Philadelphia
Mentzer: Mentzer, Bush & Co., 31 E. 10th St., New York
Nelson: Thomas Nelson & Sons, 381 Fourth Ave., New York
Owen: F. A. Owen Publishing Co., Dansville, New York
Oxford: Oxford University Press, 114 5th Ave., New York
Page: Charles N. Page, Des Moines, Iowa
Popular Mechanics Press, 200 E. Ontario St., Chicago
Putnam: G. P. Putnam's Sons, 2-6 W. 45th St., New York
Rand: Rand McNally & Co., 536 S. Clark St., Chicago
Root: A. I. Root Co., Medina, Ohio
Row: Row Peterson & Co., 1911 Ridge Ave., Evanston, Illinois
Sanborn: Benj. H. Sanborn & Co., 15 W. 38th St., New York
Scribner: Charles Scribner's Sons, 597 5th Ave., New York City
Sears: J. H. Sears & Co., Inc., 114 E. 32nd St., New York City

Simmons-Boardman: Simmons-Boardman Publishing Co., 30 Church St., New York
Slingerland-Comstock Co., Ithaca, New York
Stanford: Stanford University Press, Stanford University, California
Stokes: Frederick A. Stokes Co., 443 4th Ave., New York
Stratford: Stratford Co., 289 Congress St., Boston, Mass.
Sully: George Sully & Co., 114 E. 25th St., New York City
Thomas: Charles C. Thomas Co., 2249 Calumet Ave., Chicago
University of Chicago Press, 5750 Ellis Ave., Chicago
Viking: Viking Press Inc., 30 Irving Place, New York City
Volland: P. E. Volland & Co., 58 E. Washington St., Chicago
Webb: Webb Publishing Co., 55 E. 10th St., St. Paul, Minn.
Wiley: John Wiley & Sons, Inc., 440 4th Ave., New York
Williams: Williams & Wilkins Co., Mt. Royal & Guilford Aves., Baltimore, Md.
Winston: John C. Winston Co., 1006 Arch St., Philadelphia
World: World Book Co., Park Hill, Yonkers-on-Hudson, New York

VALUES OF SCIENCE CLUBS.

By OVE S. OLSON,

Gustavus Adolphus College, St. Peter, Minn.

Following are the values ascribed to science clubs by those who have had longest and most intimate contact with them:

1. A broadening and finding scheme for high school pupils.
2. Deepen interest in science and in school as a whole.
3. Supplements decidedly the class work.
4. Pupils preside and learn how to conduct a meeting.
5. Pupils have the opportunity to prepare thoroughly on a subject in all its phases. Teaches thoroughness of study.
6. Learn many things they would never get in regular science courses.
7. Improves discipline in school.
8. Provides avenue for choice of life work.
9. Taught accurate observation and ability to report that observation.
10. Pupils become entirely responsible for the success of an undertaking.
11. Club work helps make class work more effective.

Hunter, reporting on "What a Science Club Can Do for the School as a Whole," lists the following:

1. Social meetings gave contacts with students.
2. The beginnings of a wider scope of activity outside school laboratory.
3. Affiliation with a great American Museum.
4. Remedied conditions in dining hall.
5. Disciplined study hall, corridors, and gymnasium.
6. Made good in other lines of work.
7. Got assembly speakers.

METAL FILMS.

By G. T. Franklin,
Lane Technical High School, Chicago.

Films in General.

When one observes the evaporation of water films from metal or glass surfaces, he is not always conscious of the significance of the film, its cause and the reason why this water film is completely removed with so much difficulty. Light oils spread over the surface of water and seem never to evaporate. All of these films are visible. There are so many examples, however, in which the film is not visible but may be shown to exist. A piece of freshly heated charcoal is inserted in a tube of ammonia collected over mercury. The mercury rises rapidly in the tube, indicating the removal of the ammonia. When the charcoal is observed there is no apparent change in its composition, only the odor of ammonia from it indicates that something has happened. The manufacture of gas masks for the removal of certain poisonous gases from air to be breathed is based upon the principle that some substances have capacity to form films on their surfaces. Some of the most interesting phenomena, pertaining to films are those theoretical conditions involved in explaining why polarization, overvoltage, etc., exist.

Polarization, Overvoltage.

There are several different kinds of polarization. This discussion will be confined to that which is closely related to metal films. The usual method of explaining the rapid fall in current from an ordinary galvanic cell is based on the formation of hydrogen on the copper electrode. If the plate is scraped or heated, its activity is renewed and works the same as before until polarization takes place again. On account of the extreme volatility of hydrogen these methods of removing it from copper surfaces may be puzzling to the beginner. The presence of a persistent film of hydrogen on copper suggests a condition analogous to that of charcoal used in gas masks for the absorption of poisonous gases. Different theories have been written to explain the nature of such hydrogen films. The best of these theories and the one probably destined to be proved

correct assumes the formation of atomic hydrogen on the copper, which in the circumstances, requires work to convert it into molecular or gaseous hydrogen. This accounts for increased resistance in the circuit of a galvanic cell and an increased potential necessary to form hydrogen by electrolysis using copper electrodes. While this increased potential for copper is measurably higher, it is strikingly high in case of mercury, lead, and above all most noticeable for zinc and cadmium.

Electrolytic Rectifiers.

If an alkaline electrolytic cell is set up using aluminum electrodes and high voltage (110) is turned on, it will be found that the current rapidly diminishes and a small lamp in the circuit goes out. If direct current is used and one of the electrodes of aluminum is replaced by lead, the current will be found to go one way very well but not the other. Hydrogen forms on the aluminum electrode when current passes. A brown film forms rapidly on the lead electrode indicating the formation of oxygen there. If A. C. house current is used, it will be found to flow continuously and if the cell is working properly, D. C. current comes from the cell. The writer has used this method when only A. C. current was available to demonstrate electrolysis of water, electromagnetism etc., by suspending in a beaker of baking soda solution a plate of aluminum and a plate of lead connected in series with a lamp and any other device being used. If two such cells are connected in series, the rectification of the current is more nearly complete.

It is interesting to note the difference in behavior between films formed on lead and aluminum. One may see the formation of a film on a lead electrode and then by reversal of the current the film may be observed to disappear as if it were a water film evaporating from a metal surface. Of course two lead electrodes should be used in this experiment. The explanation in this case is simple in that the formation of lead peroxide on the anode is visible and just what is expected. On the other hand, when the current is reversed the liberation of hydrogen on the lead peroxide would be expected to deoxidize the lead peroxide and consequently its removal. That the hydrogen

which produces this effect is not molecular may be demonstrated by placing a strip of lead coated with lead peroxide in a vessel of gaseous hydrogen. It will remain indefinitely without change.

The formation of aluminum oxide on an aluminum anode is what one would expect. This coating, like that of lead peroxide on lead, is conducting but not deoxidized by hydrogen when the current is reversed. The extreme stability of aluminum oxide makes any such assumption illogical. When oxygen is formed on lead peroxide coating, the coating is still conducting. The deposition of oxygen on an aluminum oxide coating forms a non-conducting surface. When a rectifier cell of aluminum and lead is used the oxygen coating formed on the aluminum anode is evidently thin and forms during the initial part of the cycle. When the current reverses, the removal of the oxygen film during the initial part of the cycle takes place due to the combination of atomic hydrogen with what is apparently atomic oxygen. Thus the current flows when hydrogen is being liberated on the aluminum and not when oxygen is liberated on this electrode. The action of the cell seems to be due, therefore, to the formation of an aluminum-aluminum oxide-oxygen electrode, which is non conducting.[1]

ELECTROLYTIC CONDENSERS.

Many radio fans, who have passed through the rapid development of their pet hobby, may wonder why small electrolytic condensers have such large capacities. This is explained by keeping in mind that the capacity of a condenser depends in a small way upon the nature of the material between the plates called the "dielectric" and in a much larger way to the thickness of the dielectric. If it were possible to reduce the thickness of the dielectric to a uni-molecular layer, its capacity would be enormously increased. Of course such a condenser would not be able to stand a very high voltage. The dielectric of an electrolytic rectifier is apparently a thin film of non-conducting material. Aluminum is generally used in these condensers and an oxide film is carefully formed before the condenser is put to work.

[1]Creighton and Fink, "Electro-Chemistry," Vol. I, p. 231, John Wiley & Sons, New York City, (1927).

Passivity of Metals.

It is well known that dilute nitric acid reacts with steel readily, while concentrated acid may not show any appreciable action. The formation of an insulating film in such cases is likely. Analogous cases are too well known to need more than mention, such as the formation of a coat of copper fluoride on copper which resists any further action of fluorine. The formation of a coating of lead sulfate prevents further action of sulfuric acid on this metal. These types are different in that the coating is perceptible and its composition determined by ordinary processes of analysis. In such cases as that of nitric acid and iron, the nature of the film is not so easily recognized. One would expect the formation of nitrogen peroxide in this case, which may form a film on the iron. It has been predicted that what is called "passivity of metals" may turn out to be "an example of pure polarization."

A NEW LIGHT MEASURING INSTRUMENT.

An instrument has recently been developed which reads illumination intensities with the same ease and facility as reading ammeters and voltmeters. This instrument was developed by the Westor Electrical Instrument Corp. of Newark, N. J., and is known as their Model 603 Illuminometer.

It consists of an indicating instrument and a light target assembled in a portable case. The light target is on the end of a flexible cord so that it may be placed in any position. This light target or searching unit has two Photronic Cell units which convert light energy directly into electrical energy without the use of batteries or other auxiliary voltage. They maintain constant output over long periods of time and there is no dark current. The output from the Photronic Cell units is considerable, allowing the use of a rugged portable instrument calibrated directly in food-candles.

There are three ranges on the instrument, namely 10, 50 and 250 foot-candles. A range changing switch is provided for the selection of the desired scale. Other combinations of ranges are being added to the line and will be available shortly. The light target may be placed at a distance from the observer so that shadows and lights reflecting from light clothing will not cause errors in readings. Light may be read from all angles and the light target may be placed in relatively inaccessible places, in show cases, windows, etc. The absorption of light by painted walls, screens, draperies, etc., can be measured directly by turning the light target so that it faces the surface.

FIELD TRIPS FOR LARGE CLASSES.

By Fred R. Clark,
Southeastern Teachers College, Durant, Okla.

It is one thing to take a small class into the field and quite another to take out a large sized one. A large class is hard to handle, hard to keep together, hard to talk to and hard to maneuver. The instructor has to keep after stragglers in the rear, hold back adventurers in the front, keep order and manage to shout out his lecture on points of interest in the intervals between his various police duties!

A class of six or seven is about the size of the field class that one should handle. Ten or fifteen can be cared for on a pinch but to take out from thirty-five to forty students is almost a waste of time. Still sometimes we need to do this very thing, especially in beginning Biology, Forestry, Agriculture or Geology classes. For this sort of thing the writer has had some success with the following plan. A "captain" or leader is selected from among the students in the course to take charge of six or seven students in the field. In a large course several captains will therefore be needed to take care of the numerous groups. These captains are called into the instructor's office beforehand and informed as to their duties on the trip. They are told that each one has charge of a group or "party" in the field. They are to see that each student follows the plan of work laid out and that each does his proper share. The captain is to report all cases of shirking, absence and the like. He is to start his party on its way, take it to its destination and see that the work is done. The captain is to be excused from the work of the party as he will be engaged most of his time in directing the work of the others.

To illustrate how this works out in practice we can use a case from the field of Animal Biology. There are thirty-five students in the class. These are divided into groups of six, each with a captain. The captains have a list of their men and typewritten directions. They assemble their groups and start for the woods where observations are to be made. The instructor may follow or

may precede the class as he chooses, or perhaps go along with them provided he does not interfere with the groups. His presence should be for advisory purposes only. Authority has been delegated to the captains and they should be given plenty of leeway to handle their parties. Each captain as the groups arrive at the scene of operations chooses a suitable site for the work, gets his group about him and explains what is to be done. Then he starts the members to work and sees that the observation is carried thru to completion. When completed he returns with his party to the schoolroom where any observations made can be written up and handed in to the teacher.

As a Biology field trip one might well use a simple ecological study, suited to beginners, designed to interest them in natural things and create the habit of observation. This would be worked out by the students and handed in as a group report. For this the captain's typewritten outline would be something like this:

1. Members of the party.
2. Date.
3. Location of the site observed.
4. Size of area observed.
5. Nature of the site: topography, earth features, drainage, exposure, lakes, streams, roads, etc.
6. A sketch map of the area, properly labeled to show all features.
7. Nature of the vegetation over the area: plant associations, types of vegetation, common species, etc.
8. A list of the animals found to be present on the site. This list to be arranged in tabular form with each animal classified as to its phylum, class if possible, and perhaps genus and species. A note should be made as to where the animal was found.
9. A list of all animals on the area that are not properly native to the region and have been introduced from other countries, like the domestic animals, exotic birds, introduced insects.
10. A list of any poisonous animals noted: as certain snakes, insects, spiders, scorpions, centipedes.
11. Notes on any matters of ecological interest such as societies, associations, changing environments.

With such a brief outline as is here given the writer has obtained excellent results from large classes. The change from laboratory routine to field observation never fails to arouse great enthusiasm among the students which will be carried back into their laboratory work upon return. About all that the instructor needs to do is to visit each group once or twice while they are at work in order to answer questions or to assist in deter-

mining some unfamiliar specimen. It should be emphasized that these parties run themselves and that interference upon the part of the teacher will be likely to impair their work. This field method has been used by the writer in classes of Botany, Zoology, Biology and Forestry. All that one needs to do is to vary the nature of the exercise to fit the requirements of the subject matter. Doubtless it has its limitations and deficiencies, but it is offered to others as a possible aid in overcoming their difficulties. Certainly it has helped the writer.

PROBLEM DEPARTMENT.

CONDUCTED BY G. H. JAMISON,
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS OF PROBLEMS.

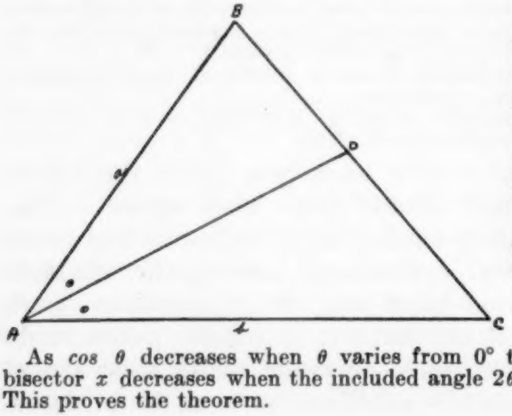
Editor.—Persons sending in solutions should read carefully the instructions about the form of the solutions and the ink-drawn figures. Many times, a good solution is received, but poorly arranged and no India-ink figure given.

1187. *Proposed by Merton Cuthbert, Los Angeles, California.*

If two triangles have two sides of one equal to two sides of the other, prove that the greater included angle has the shorter bisector.

TRIGONOMETRIC SOLUTION.

Solved by W. E. Buker, Leetsdale, Pa.



Let the sides be a and b, and the included angle 2θ. $BD/DC = a/b$ Let $BD = ar$; $DC = br$; the bisector $AD = x$.

By the law of cosines,

$$a^2r^2 = a^2 + x^2 - 2ax\cos\theta;$$

and

$$b^2r^2 = b^2 + x^2 - 2bx\cos\theta.$$

Eliminating the r's,

$$(a^2 + x^2 - 2ax\cos\theta)/a^2 = (b^2 + x^2 - 2bx\cos\theta)/b^2$$

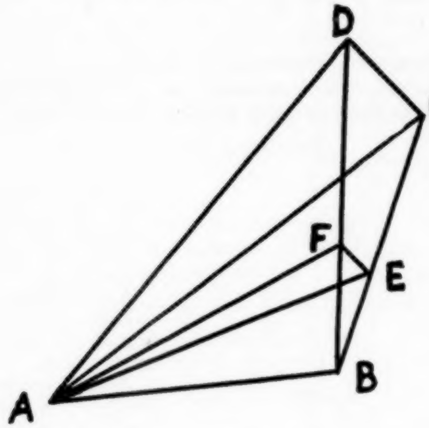
Simplifying and solving for x,

$$x = \frac{2ab}{a+b}\cos\theta.$$

As $\cos\theta$ decreases when θ varies from 0° to 90°, the value of the bisector x decreases when the included angle 2θ varies from 0° to 180°. This proves the theorem.

GEOMETRIC SOLUTION.

Solution by proposer.



Given triangle ABC with bisector AE, and triangle ABD with bisector AF. AB is common to both triangles; and AC = AD. Connect CD and EF.

$\frac{AB}{AC}=\frac{BE}{CE}$; and $\frac{AB}{AD}=\frac{BF}{FD}$.

$AC=AD$

$\therefore \frac{BF}{FD}=\frac{BE}{CE}$

$EF \parallel DC$

$\therefore \angle BCD = \angle BEF$

$\angle BCA < \angle BEA$

By subtraction

(1) $\angle ACD > \angle AEF$

In a somewhat similar manner it can be shown that

(2) $\angle AFE > \angle ADC = \angle ACD$

Hence from inequalities (1) and (2) we find in $\triangle AFE$,

$$\angle AFE > \angle AEF$$

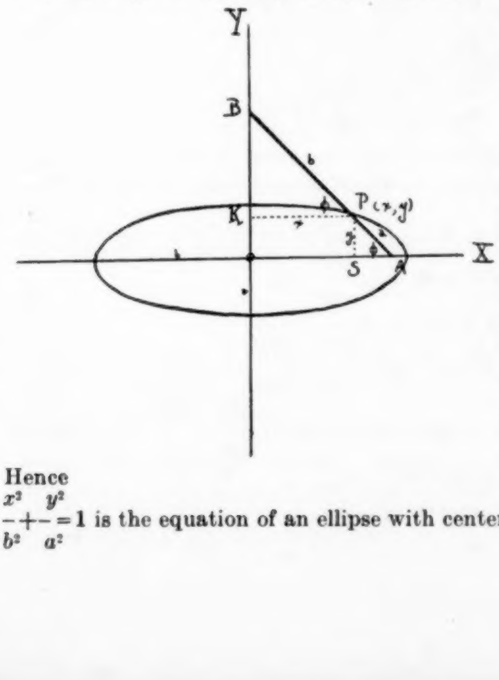
and hence $AE > AF$.

Also solved by R. T. McGregor, Elk Grove, California; A. J. Patterson, Wheeling, W. Va.; and Arthur J. Kavanaugh, Washington, Conn.

1188. *Proposed by Greeta Gibson, Iowa City, Iowa.*

Find the locus of a point, P, on a line of constant length that moves so that its extremities, A and B, are on the X and Y axes respectively. The point, P, is at the distance a from A, and the distance b from B.

Solution by William C. Nelson, Hampton, Va.



Let P (x, y) be the point.

$\angle BPK = \angle PAS = \angle \phi$

then

$x = b \cos \phi$ (1)

$y = a \sin \phi$ (2)

(1) and (2) are parametric equations of the point $P(x, y)$, which are parametric equations of an ellipse.

The locus of the point, P, is then an ellipse.

However, the parameter (ϕ) may be eliminated from (1) and (2)

$\frac{x}{b} = \cos\phi$ $\qquad$ $\frac{y}{a} = \sin\phi$

Squaring and adding.

$$\frac{x^2}{b^2}+\frac{y^2}{a^2} = \cos^2\phi + \sin^2\phi = 1 \qquad (3)$$

Hence

$\frac{x^2}{b^2}+\frac{y^2}{a^2}=1$ is the equation of an ellipse with center at 0, the required locus.

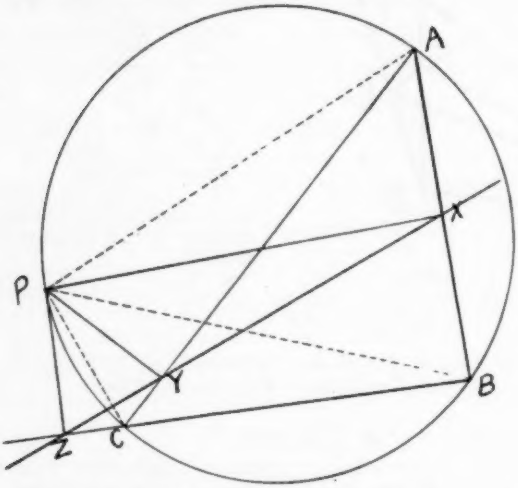
Also solved by W. E. Buker, Leetsdale, Pa.; Victor R. Cox, Wichita, Kansas; W. E. Batzler, Battle Creek, Michigan; A. J. Patterson, Wheeling, W. Va.; Leo. H. Aroian, Fort Collins, Colo.; Arthur J. Kavanaugh, Washington, Conn.; and Herman Goldstein, Brooklyn, N. Y.

1189. *No solution received.*

1190. *Proposed by Walter H. Camahan, Indianapolis, Indiana.*

By use of the theorem of Menelaus (The Converse) prove that the feet of the perpendiculars dropped upon the sides of a triangle from any point on the circumcircle are collinear.

Solution by Frank B. Allen, Sparta, Ill.



Draw PX, PY, PZ $\perp$ to AB, AC, BC.

Join P to A, B and C.

Angle CBP = angle PAC; angle PCA = angle PBA.

Also angle PCZ = angle PAX since each is supplementary to angle PCB.

From the equality of the above angles we have the following right triangles similar.

$\triangle PCY \sim \triangle PBX$ $\quad$ $\triangle PBZ \sim \triangle PAY$ $\quad$ $\triangle PAX \sim \triangle PCZ$

Whence:

(1) $\frac{BZ}{AY} = \frac{PZ}{PY}$ $\quad$ (2) $\frac{CY}{XB} = \frac{PY}{PX}$ $\quad$ (3) $\frac{XA}{ZC} = \frac{PX}{PZ}$

Forming the continued product of (1) (2) and (3)

$$\frac{BZ}{AY} \cdot \frac{CY}{XB} \cdot \frac{XA}{ZC} = 1$$

$\therefore$ Points X, Y and Z are collinear by the converse of Menelaus Theorem.

Also solved by A. J. Kavanaugh, Washington, Conn.; and W. E. Buker, Leetsdale, Pa.

1191. Given:—Fixed circle R and fixed point O, P a variable point on circle R, Q a point on OP such that $\frac{OQ}{OP} = K$

To Prove:—The locus of Q is a circle.

1. Draw OR, and locate R′ such that $\frac{OQ}{OP} = \frac{OR'}{OR} = K$, and draw QR′.
2. Then regardless of P's position on the circle, $\frac{OQ}{OP} = \frac{OR'}{OR}$ and since $\angle O$ is common $\triangle OQR \sim \triangle OPR$.
3. $\frac{QR'}{PR} = \frac{OR'}{OR} = K$ or $QR' = K \cdot PR$ = a constant.

4. Since R' is a fixed point and QR' is a constant length, point Q traces out a circle.

This problem is discussed in Altshiller-Courts College Geometry, P. 41, under the heading "Homithetic Figures."—Editor.

Also solved by W. E. Buker, Leetsdale, Pa.; Leo A. Aroian, Fort Collins, Colo.; William C. Nelson, Hampton, Va.; A. J. Kavanaugh, Washington, Conn.; and A. J. Patterson, Wheeling, W. Va.; Charlotte Phillips, Hampton, Va.

1192. *Proposed by S. Chuang, Shanse, China.*

Solve this set of equations:

$$X^2-Y^2=XY-1$$
$$X^3+Y^3=X^2Y^2-1$$

Solved by Louis R. Chase, Newport, R. I.

Calling these equations (1) and (2); dividing (2) by (1), and reducing to lowest terms, we have

$$(3)\quad \frac{X^2-XY+Y^2}{X-Y}=XY+1$$ [This step excludes $X+Y=0$, $XY-1=0$, from which we obtain $X=i$, $Y=-i$; $X=-i$, $Y=i$.

Putting $Y=mX$ in (3), and reducing to lowest terms we have

$$(4)\quad \frac{X(1-m+m^2)}{1-m}=mX^2+1.$$

This step excludes $X=0$, in which case $Y=-1$.

From (4), $X=\dfrac{1}{1-m}, \dfrac{1-m}{m}.$

$$Y=\frac{m}{1-m},\ 1-m, \text{ respectively, since } Y=mX.$$

Putting the first pair of these values in (1) and solving, $m=\dfrac{2}{3}$, whence $X=3$, $Y=2$.

Putting the second pair of values in (1) and simplifying,

$$m^4-m^3-3m^2+3m-1=0.$$

This equation, which leads to the irreducible case, has for its only real roots, 1.89470356 and −1.78897316, approximately. By the use of 7-place log. tables, these yield the approximations listed below.

$X=$	i	$-i$	0	3	−0.4722128	−1.558980
$Y=$	$-i$	i	−1	2	−0.8947036	2.788973

Solved, partially, by Samuel M. Cohn, Philadelphia, Pa.; A. J. Patterson, Wheeling, W. Va.; and A. J. Kavanaugh, Washington, Conn.

The Editor would like, as suggested in the last issue, to make honorable mention of high schools whose classes in mathematics or mathematical clubs make noteworthy contributions to this Department. Teachers are urged to make report of such contributions.

PROBLEMS FOR SOLUTION.

1205. *Proposed by Albert Whiteman, Philadelphia, Pa.*

Show that any number of the form x^n is the sum of consecutive odd integers.

1206. *Proposed by A. Strunk, Paterson, N. J.*

In $\triangle ABC$, AD bisects $\angle BAC$; M is a point on AB, and N a point on AC, such that $BM=CN$; R is the midpoint of MN, S the midpoint of BC. Prove that AD and RS are parallel.

1207. *Proposed by Harry Frye, Tullahoma, Tenn.*

I have a plot of ground in the shape of a trapezoid. One base is twelve feet long and the other is six feet long. The two sides are each one hundred and forty feet long. I wish to build a walkway through this plot of ground parallel to the bases, with one edge of the walkway passing through the center of gravity of the plot and the other edge dividing the plot of ground into two equal areas. Just where and how wide shall I build this walkway.

1208. *Proposed by W. E. Buker, Leetsdale, Pa.*

A straight rigid rod of length 1 moves so that one end describes a circle, while the other end oscillates back and forth along a straight line which, if prolonged, would pass through the center of the circle. Find the locus of a point P on the rod.

1209. *Proposed by A. J. Patterson, Wheeling, W. Va.*

Prove that the difference of the squares of any two numbers divided by twice the greater gives a quotient which when squared and added to the square of the lesser number gives a perfect square.

1210. *Proposed by Leo Aroian, Fort Collins, Colo.*

To chart the position, P, of a sunken wreck three points A, B, C, in a straight line are marked on the shore and an observer at P in a small boat measures the angles APB and BPC. Show how to find AP, BP and CP.

A FORMULA FOR SQUARING INTEGERS BETWEEN 25 AND 75.

If the squares of integers from 1 to 25 are known, integers between 25 and 75 may be squared conveniently by using the identity

$$(25+n)^2-(25-n)^2=100n.$$

Thus, to find the square of 38 we note that $n=38-25=13$. Hence $38^2=1300+144=1444$.

To find the square of 62 we note that $n=62-25=37$. Hence $62^2=3700+144=3844$.

This method of squaring integers was discovered by Miss Virginia Van Riper, a student in the Pontiac (Michigan) High School.

We may add that if the squares of integers up to 25 are known we may use the identity

$$(50+n)^2-(50-n)^2=200n$$

to find the squares of integers from 75 to 100.—J. M. K.

A NOTE ON FROGS.

By D. G. VEQUIST, *St. Joseph, Mo.*

Frequently we keep frogs thru the winter from season to season in the biological laboratory. The common frog (rana pipieus) may be domesticated by keeping in an ordinary box with the top covered with course screen which lets the flies in but retains the frog. The box is tilted on one side and a board loosened so the frog can be watered since frogs must have water available at all times. By installing a light in such a box placed out of doors it becomes automatic as a provider of good. Frogs have an insatiable appetite for nice juicy cockroaches. Frogs will swallow any kind of insect from a bumble bee to a large grasshopper or even hard beetles, but they show much more eagerness when they can procure soft bodied insects.

A SIMPLIFIED METHOD FOR THE DETERMINATION OF THE WAVE LENGTH OF LIGHT.

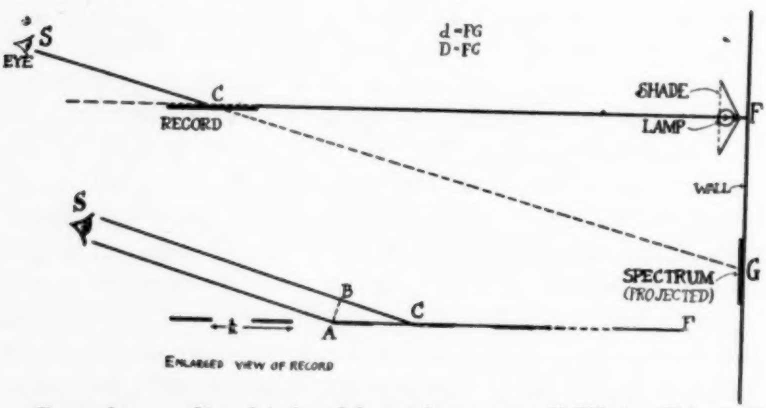
BY LUIS ALVAREZ,

Chicago, Ill.

The wave length of light may be measured with the aid of a phonograph record, an electric light, and a meter stick. If the reflection of an electric light in the surface of a phonograph record is viewed at a large angle of incidence, it will be seen to be accompanied by several spectra. From measurements of the spectrum closest to the reflected image, the wave lengths of the various colors of the rainbow may be calculated. The record is used as a coarse diffraction grating, and a spectroscope is not needed.

A piece about two inches wide and as long as the grooved portion of the record is broken from the disk. On this piece, the grooves will be almost straight and parallel, as on a reflection grating. The only other piece of apparatus needed in the experiment is an electric bulb with some sort of reflector or shade attached to it. The reflector should be arranged to throw the beam horizontally, and with equal portions above and below the center of the bulb. The lamp is placed against a wall at a distance of five or ten meters from the observer. The latter should be seated directly behind some support for the record, such as the back of a chair. The record is held in the hand in a nearly horizontal position, and the eye is placed as close to it as possible, and directed downward. The record is held so that it may be rotated about a horizontal axis, which is perpendicular to the line joining the lamp with the observer. It is placed before only one eye; the other is used to determine the position of the spectrum on the wall in relation to the lamp. On looking into the record, a reflection of the lamp and its reflector will be seen. If a line joining the lamp and the record is in the surface of the latter, it will be impossible to see the image of the former. But in this case, the image of the upper edge of the shade will coincide with its lower edge, as seen with the other eye. The spectrum will still be seen plainly enough for the purposes of the experiment. Its position on the wall

below the lamp should be noted roughly, and a sheet of paper crossed with lines about an inch apart should be pinned on the wall so that the apparent position of the spectrum is on the paper. The lines should be numbered in large numbers for convenience in identification at a distance. Now, any color such as red, will be chosen on which to make the measurements. The record is held in the hand as described before, and steadied on the rest to prevent vibration. It is adjusted so that the image of the shade coincides with the shade as seen in the other eye. Now, the first spectrum will appear to be located on the wall behind the lamp, and the red portion of it will fall on one of the lines drawn on the paper, or between two of them. The particular line is noted by its number, and the distance from this line to the point directly in back of the center of the lamp is measured with a meter stick. The distance from the wall to the position occupied by the record is also measured. The number of grooves per centimeter is determined by using a low powered microscope, or by counting the number of revolutions necessary to move a needle a distance of one centimeter across the disk. Representing these three figures by d, D, and n, respectively, the wavelength of red light is given by the relation: wavelength$=\frac{d^2}{2nD^2}$ cm. In this manner, the wavelength of any color may be determined.



Sample results obtained by using a small Victor Record, and a frosted electric light globe.

$D = 762$ cm.
$n = 34.9$ per cm.
d (green) $= 46.5$ cm.
d(red) $= 52.5$ cm.

Wavelengths	Calculated	Accepted
green	0.00005340 cm.	0.00005200 cm.
red	0.00006810 cm.	0.00006800 cm.

The derivation of the formula is given below. It is based on the wave theory of light, and Huygen's Principle. (See diagram.)

Distance between grooves $= 1/n$ cm.

Path difference between SAF and SCF $= AC - BC = \lambda$, since first spectrum only is measured. (λ represents wavelength).

$$AB/AC = d/D$$

$$AB = d/Dn$$

$$BC^2 = AC^2 - AB^2 = 1/n^2 - \frac{d^2/D^2}{n^2} = \frac{1 - d^2/D^2}{n^2}$$

$$BC = 1/n \cdot \sqrt{1 - d^2/D^2}$$

$$AC - BC = \lambda = \frac{1}{n} - \frac{1}{n}\sqrt{1 - \frac{d^2}{D^2}} = \frac{1 - \sqrt{1 - \frac{d^2}{D^2}}}{n} = \frac{1 - 1 + \frac{1}{2}\frac{d^2}{D^2} + \text{-------}}{n} \quad \text{(neglect)}$$

$$\lambda = \frac{d^2}{2nD^2}$$

BEAUTY IN BOTTLES.

By Helen Field Watson,

421 East Fourth Ave., Mitchell, So. Dak.

There are two theories of the way to make a child love beauty—one, that if he has nothing of beauty in his environment he will create it in his mind to satisfy a natural craving for loveliness; the other that beauty of surroundings becomes imperceptibly a part of one's self. The second theory seems to be recognized in the elementary schools. Now-a-days these grade rooms are indeed laboratories. Perhaps, then, if we can have a generation of patience, beauty will by that time have reached the high school and college work-shop. For why should not laboratories be lovely spots?

Or are these places now attractive from the aesthetic standpoint? From the hundreds of hours which I have spent as a student in laboratories, aside from calendars advertising local business houses or a scientific supply company, I can recall just one picture, a framed picture of a rheostat. Memory may be faulty or my absorption in

science may have caused attractive pictures to hang unnoticed. It may have been so, but I am quite sure such was not the case. For the "Aurora" in a Latin room imprinted itself upon my fourteen-year-old mind and soul. It furnished something of a zeal for learning that an eight o'clock class failed to stir. Mercury—a tiny bronze Mercury—also in a Latin room must have been aware of frequent and approving glances when Caesar or Cicero or Virgil were not needing my eyes. There are other memories of art pieces in classrooms. Without question each one has influenced a yearly and multi-yearly roll of students. Such values can not be made a matter of invoice.

But is there some reason why science laboratories should be plain? The question is asked with real uncertainty, for it would seem when a condition is so general there must be a reason for it. There is precedent as an explanation, precedent the scoundrel which has killed many an ambition. Of course this same precedent sometimes turns out to be the hero. I am wondering if it is true in this case.

A laboratory has a purpose other than an auditorium. It is a place to work with materials, just as is a kitchen or a greenhouse. There must be bottles and balances and dynamos and insect cages and petrie dishes, so on ad infinitum. One teacher, not a science teacher, recently used the expression in connection with a project "it gives the room the appearance of being a busy place." Perhaps that has its value. But it seems that as Americans we are inclined too largely to appear to be busy, that our greater need is an opportunity to cultivate a habit of repose. Granting that there is some value in having the room appear to be a busy place, whether in influencing the principal in rating the teacher or infiuencing the child to think of the school-room as a place of industry, I still persist in asking my question though altering it: Need a laboratory be a cluttered, unlovely place?

It is easy to imagine the purpose of a laboratory being forgotten or neglected while the room is being transformed into a beauty spot. Nothing is more provoking to a research student in bacteriology than to find that a culture he left at a constant temperature in the oven has

been set out onto the shelf by some careless colleague, nor to a student experimenting on the intensity of light needed for certain rates of growth of a plant to have his work relegated by an assistant to the dark stock room just to get it out of sight. To the mycologist molds are not unsightly, to the chemist reagent bottles are necessities, to the physicist a dynamo is power, to the mammalogist a partly dissected carcass has a significance which offsets its unattractive qualities. Perhaps we have here the whole answer to our question: Need a laboratory be an ugly spot? Perhaps the answer is "each in his own tongue."

And it may be the question—for it is not yet answered to my satisfaction—should be: Is there not a place in every science laboratory for the aesthetic things? Just now you have glanced at the name of the writer of this article to corroborate your "of course it was written by a woman." It was. Yet it was a boy who came in to see how I got Paper White Narcissus blooms so early. It was a boy who stopped to express appreciation of Joyce Kilmer's "Tree"—a parchment copy by the pencil sharpener. It was a boy who expressed his fancy for a certain wall vase. He had brought the vines it held. It was another boy who told me my vases were beautiful and that he liked, in particular, a yellow Rookwood piece. It was a boy who remarked about the beauty of a certain splotch of color, a boy who sent me Lycopodium for Christmas wreathes for the laboratory, a boy who suggested that we needed a new picture to replace a framed advertisement of a railway in the foreground of Niagara Falls. He it was who helped select to replace it Corot's "Allee des Arbres." It was a young man who came into the laboratory where he had once studied with the comment, "It is lovely in here. I used to think this the dreariest room in the building. I guess it is the pictures." Many girls have made comments too, but I mention some of the boys' remarks to show why I believe they are sensitive to loveliness.

No doubt there are two undesirable conditions in laboratories—extreme orderliness and extreme disorderliness. Experiments must often be left exposed. But a fern in a hanging basket makes the apparatus no more conspicu-

ous. Those corroded pans which were being used as seed germinators had to remain for many days where you saw them, but perhaps you were so attracted by that mass of color on the other wall that you would not have noticed the pans had I not mentioned them. The color? Was it a bouquet of autumn leaves, or a picture, or a vase? I do not recall.

A tadpole may be given a clean jar, a bright shell for a hiding place, and a spray of myriophyllum. The tadpole then becomes a bouquet, or the ensemble, at least, has three of the qualities desirable in a bouquet besides having biological values.

I once thought—perhaps I had not given it a thought—that my vases were too expensive to use in the laboratory. Then one student suggested that we needed "some baskets or something for our flowers." Since then many young people have absorbed the charm of a few pieces of good pottery. Experiments are not only necessary but interesting. But they are no less interesting if a spray of apple blossoms carries indoors the odor of spring.

Beauty of surroundings does not preclude industry. My belief is that it enhances work by bringing attention and memories into the immediate environment and so leaving less to distract desire.

Few folks there are who are not happier with flowers, good pictures, and color harmonies about. Laboratories should be lovely spots.

SCIENCE QUESTIONS

January, 1932

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

LIVING BACTERIA 200 MILLION YEARS OLD.

"The oldest living creatures in the world have been found near Pottsville, Pa. They are living bacteria dating back 200,000,000 years. They were on a lump of anthracite coal 1,800 feet under ground. Their discoverer, Prof. Lipman, University of California, found their abiding place was free of water or of living matter of any kind. He believes they were entombed with the coal. The bacteria are so small that a microscope of 2,000 diameters is required to see them, but when placed in a suitable environment they multiplied rapidly . . . . Talk about the survival of the fittest, what would Darwin have thought about that?"

LIGHTNING.

592. What is Lightning? How many kinds or varieties are recognized by scientists? Which kinds have you seen?

(A possible answer is found in *Literary Digest*, Oct. 10, 1931, page 22 and following.)

QUESTIONNAIRE ON SCIENCE CURRICULUM.

593. *Answer to Questionnaire by J. R. Bullington:*

"The Science program in our local junior high schools is in process of reorganization. We know that anything resembling a questionnaire is an abomination in the eyes of school men but we are very anxious to have your opinion as to what Science should be taught in each of the junior high school grades and how much time should be used. The inclosed blank indicates the exact information desired and the envelope is for your convenience.

"Your help in this matter would be deeply appreciated.

"Respectfully yours,

"J. R. Bullington."

WHAT IS YOUR ANSWER?

Here is the answer sent in by the *Editor*. Please criticize his answer and send in your own answer to the *Editor*. He will forward them to Mr. Bullington.

RECOMMENDATION FOR SCIENCE PROGRAM IN JUNIOR HIGH SCHOOL.

Name: Mr. Franklin T. Jones

Address: 10109 Wilbur Avenue, Cleveland, Ohio

Grade	Required or Elective	Number Weeks Taught	Number Periods Per Wk.	Length of Period	Units of Subject-Matter
7th	Required	36	2 or 3	40-45 min.	Geology—about 12 weeks. Astronomy—about 12 weeks. Plants and/or Animals and/or Birds—12 weeks.
8th	Required	36	3 or 2	40-45 min.	Plants and/or Animals and/or Birds—12 weeks Astronomy—about 12 weeks. Geology-about 12 weeks. } Not a duplicate, nor amplification of 7th Grade work, but NEW stuff.
9th	Required	36	4 or 5	40-45 min.	EXPERIMENTAL CHEMISTRY or PHYSICS } Not a hodge-podge of "General Science." (Compare English Courses in Experimental Physical Science.)

A QUESTION FOR BIOLOGISTS.

594. Put water in your paste pot—just enough to soften up the paste. Close it up. After a week tell the *Editor* what makes the scum of mould or bacteria or what have you.

WANTED—THOUGHT PROVOKERS.

581. (Repeated from October, 1931, p. 877.) What "Thought Provokers" have you? Read those sent in by Paul Miller and send in some of your own.

TESTS IN PHYSIOGRAPHY.

590. "I would like you to send a copy of Test Questions on Physiography," John Koors, Jr. (Please send to the *Editor*.)

See SCHOOL SCIENCE AND MATHEMATICS, "Science Question 553,"

May, 1930. *Tests in General Science* by Miss Opal Burres, West Technical High School, Cleveland.

Following are *four* tests in Science:

1. Physical Geography, Boston University, 1929.
2. Same, Rensselaer Polytechnic Institute, Form R-8.
3. Physical Science, Province of Alberta, 1920.
4. General Science, Regents, State of N. Y., 1931.

Boston University, College of Liberal Arts, Entrance Examinations.

PHYSICAL GEOGRAPHY, September, 1929.

Time: one hour and thirty minutes.

GROUP A (Answer one question.)

1. Describe all motions of the earth and their effects.
2. Explain the division of the earth's surface into standard time zones.

GROUP B (Answer one question.)

3. Discuss the depths of the oceans, and the topography of the bottom.
4. Describe the important ocean currents of the globe.

GROUP C (Answer two questions.)

5. Discuss the importance of atmospheric pressure in relation to other atmospheric conditions.
6. Describe the wind systems of the globe.
7. List all influences which affect the climate of New England.
8. Give the principles of weather forecasting.

GROUP D (Answer three questions.)

9. Describe the development of alluvial (or flood) plains by rivers.
10. Describe the valley type of glacier.
11. Describe the shore structures which result from wave and current action.
12. Show how earthquakes and faulting may affect topography.
13. Compare the habitability of the different types of river valley.

Rensselaer Polytechnic Institute, Troy, N. Y.

PHYSICAL GEOGRAPHY.

Answer ten questions, choosing from each group as directed.

GROUP I. The Earth as a Planet. Answer two questions from this group.

1. (a) Describe the mariner's compass. (4) (b) State the meaning of (1) agonic line, (2) (2) magnetic declination, (2) (c) Locate the magnetic poles. (2)

2. (a) Make a diagram to explain a total lunar eclipse. (6) (b) State the meaning of (1) perihelion, (2) solstice, (3) equinox, (4) circle of illumination.

3. (a) Describe a method for the determination of latitude. (6) (b) How does the length of a degree of latitude vary between the equator and the poles? (2) (c) Give the same information concerning a degree of longitude. (2)

GROUP II. The Atmosphere. Answer two questions from this group.

4. (a) Mention four atmospheric conditions which are indicated on a weather map. (4) (b) By symbols show how these conditions are indicated. (4) (c) Contrast the weather in areas of high and low barometer. (2)

5. (a) State the meaning of (1) dew-point, (2) (2) humidity. (2) (b) Locate two sections of the U. S. having excessive annual rainfall and two sections having scanty rainfall and account for each condition. (6)

6. (a) Name two kinds of thermometer for recording extremes of temperature and describe the construction of one of them. (4) (b) Name two kinds of barometer and describe the construction of one of them. (4) (c) Explain a use of the barometer other than weather forecasting. (2)

GROUP III. Water. Answer two questions from this group.

7. (a) Describe icebergs as follows—origin, direction of motion and southern limit in North Atlantic Ocean. (3) (b) Compare the ice caps of the northern and southern hemispheres as to area, and account for difference. (3) (c) Compare the North Atlantic and North Pacific Ocean as to freedom from icebergs and explain your answer. (4)

8. State the conditions necessary for the formation of (a) caverns, (b) veins, (c) geysers, (d) cut-offs, (e) falls.

9. (a) Give reasons for the contrast in temperature between the surface and the depths of the ocean. (4) (b) Compare the regularity of isotherms on ocean and on land and explain any difference. (2) (c) State the causes of ocean currents and trace the course of the North Atlantic circulation. (4)

GROUP IV. The Land. Answer four questions from this group.

10. (a) Name three classes of rocks, according to origin. (3) (b) Name two rocks belonging to each class named. (5) (c) How could you distinguish between broken masses of calcite and of quartz? (2)

11. (a) State the probable causes of volcanism. (3) (b) Name three products of volcanic eruption which have economic value. (3) (c) With which age of mountains are volcanoes associated? (2) (d) What is a dike? (2)

12. Describe three types of lacustrine plain as follows: (a) Cause of each type, (4) (b) economic value of each, (3) (c) location of three lacustrine plains in the United States. (3)

13. Compare the east and west coasts of the United States as follows: (a) width of coastal plain, (b) number and kind of harbors, (c) rainfall, (d) winter temperatures explaining your answer, (e) dangers to navigation.

14. Locate in North America each of the following features: (1) an old river, (2) a rejuvenated river, (3) a drowned river, (4) a naturally dissected plateau, (5) an old plateau, (6) a rock-bottom glacial lake, (7) a regular shore-line, (8) a shore-line modified by coral, (9) a young river valley, (10) a sand dune.

15. (a) Describe the action of two chemical agents of weathering. (2) (b) Mention four mechanical agents of weathering. (4) (c) Mention four agents for the transportation of soil. (4)

Province of Alberta, High School and University Matriculation Examinations Board, University Matriculation Examination, September, 1920.

PHYSICAL SCIENCE.

Time—Two and one-half hours.

1. (a) By reference to the theory of sound waves explain the following: 1. The intensity of a sound varies inversely as the square of the distance from its source. 2. Sound waves may be reflected.

(b) Describe an experiment to demonstrate that a material medium is necessary for the transmission of sound.

(c) Why is there less reverberation in a well filled auditorium than in an empty one?

2. (a) Given a tuning fork of known vibration frequency and

other apparatus necessary, show how the velocity of sound in air may be determined experimentally.

(b) 1. Define and distinguish consonance and resonance. 2. Show how the phenomenon of consonance is practically applied in the piano and violin. 3. The length of an open tube in resonance with tuning fork A is 24 inches, and the length of a tube closed at one end in resonance with tuning fork B is 10 inches. Compare the vibration frequencies of tuning forks A and B.

3. (a) Describe an experiment to demonstrate that when a ray of light is reflected from a plane mirror, the angle of reflection is equal to the angle of incidence.

(b) Explain the phenomenon of lateral inversion.

(c) Account for the fact that on a moonlight night when the surface of a body of water is covered with ripples, a long band of light is observed on the surface extending in the direction of the moon.

4. (a) Define the following terms: Index of refraction, critical angle, conjugate foci, focal length.

(b) The focal length of a convex lens is 6 inches. A candle is placed (1) 15 inches, (2) 9 inches, (3) 4 inches from the lens. State in each case whether the image is real or virtual, erect or inverted, larger or smaller than the object.

(c) Where must an object be placed so that a convex lens may be used as a magnifying glass?

5. (a) Describe an experiment to show that white light is composite.

(b) 1. When are colors said to be complementary? 2. How would one determine experimentally the color that is complementary to blue?

(c) Why do the results obtained from mixing pigments differ from those obtained from mixing colors?

6. (a) Define the terms: Anode, electrolyte, ion.

(b) Show by means of experiments that: 1. An electric current may be produced by chemical action. 2. An electric current may be used to promote chemical change.

(c) Describe experiments to show how the strength of an electric current may be determined by measuring (1) its chemical effects. (2) its magnetic effects.

7. (a) State the condition under which an electric current may be produced in a closed circuit by induction.

(b) Explain and exemplify the statement: "The discovery of the principle of producing a current by induction made possible all the modern applications of electricity in industrial development."

(c) Describe an electric motor giving the structure and relation of the parts and showing how it transforms the energy of the electric current into mechanical motion.

8. (a) Describe the apparatus used in the production of Rontgen rays.

(b) Give three leading properties of these rays.

The University of the State of New York, 251st High School Examination.

GENERAL SCIENCE.

Tuesday, June 16, 1931—1:15 to 4:15 p. m., only.

Write at top of first page of answer paper (a) name of school where you have studied, (b) number of weeks and recitations a week in general science, giving either the total number of laboratory periods and the length of such periods or the number of laboratory exercises performed. A paper lacking the statement of laboratory work will not be accepted at a standing of less than 75 credits. The minimum time requirement, including laboratory periods, is five recitations a week for a school year.

Answer any 10 questions. Answers should be numbered and lettered to correspond with the questions. Answers to any of the last five questions should be written on the question paper as directed and handed in with the other answer paper.

1. Suppose that you are given a rectangular metal box having a glass front and two holes in the top, a lighted candle directly under one of the holes, two glass chimneys and a joss stick or piece of touch paper. a. State what you could illustrate with the apparatus. (1) b. Indicate fully what you would do and what you would observe. (4) c. Give *one* application of the principle involved. (1) d. Make a fully labeled diagram illustrating the apparatus as it would be used. (4)

2. The weather map shows that there is a "high" in Colorado and a "low" in New York. a. In what general direction are these areas of high and low pressure moving? (2) b. In which locality is the greater amount of moisture? (2) c. In which locality is it cloudy? (2) d. In which locality is it dry? (2) e. Which place has the greater air pressure? (2)

3. Describe fully a system for a city water supply that you have studied in detail. In your description give (a) reasons for selection of source, (b) how pressure is secured, (c) how the water is conveyed, (d) method of purification, (e) method of protection. (10)

4. a. Water may be boiled in a paper bag on a very high mountain and the bag will not take fire. Which of the three conditions necessary for combustion is not present in this case? (2)

b. Forest rangers frequently use dynamite to prevent the spread of forest fires. Which of the three conditions necessary for combustion is removed by the formation of this firebreak? (2)

c. If a person's clothing catches fire in a room on the floor of which there are rugs, what could you do to put the fire out? Which of the three conditions necessary for combustion would you be removing? (2)

d. If the drafts of a furnace are opened, which condition for combustion is provided? (2)

e. What are the two products that result from the burning of a candle? (2)

5. The observations below were made during a summer vacation by a member of the general science class. Explain *each* of these observations.

a. One very hot day an unusually large number of automobiles were seen parked along the concrete highway while their drivers were changing or repairing the tires. (2)

b. Some fish were taken from a near-by pond, placed in bottles of clean fresh water and fed. After a few days they came to the top of the water, gasped for a while and died a short time later. (2)

c. After applying tincture of iodine to a cut finger, a boy accidentally rubbed it against a newly laundered towel. The towel, instead of turning brown, turned blue. (2)

d. Although a glass pitcher containing ice water was carefully dried with a towel before it was set on the table, it became quite damp on the outside. (2)

e. When a new hot water kettle was examined after having been used for a month, a heavy white crust was formed on the inside. (2)

6. Tell whether each of *five* of the following statements is *true* or *false*, giving a reason in each case: (10) a. Water rises in a glass cylinder when a weight is lowered into it. b. Water is an element. c. Borax "softens" hard water. d. Kitchen utensils often have wooden handles. e. Shadows are cast by opaque objects. f. All bacteria are harmful.

7. Explain the difference in meaning between the terms in *each* of

the following groups: a. Conduction and convection. (2) b. Oxidation and combustion. (2) c. Plasma and lymph. (2) d. Element and compound. (2) e. Narcotic and stimulant. (2)

8. a. State *two* distinct harmful effects of alcoholic beverages on *each* of the following: digestion, the nervous system, respiration. (6) b. Define narcotic and give an example. Tell briefly how the effect of a narcotic on the circulatory system differs from that of a stimulant. (4)

9. Name *two* devices that depend for their operation on (a) air pressure (2), (b) compressed air (2). Describe fully with a labeled diagram the operation of *one* of the devices named in answer to a (6).

10. For each of *five* of the following give *one* reason to show that the statement is true: (10) a. All life depends on the sun's energy. b. Drying will preserve foods. c. A cracker becomes sweet when it is thoroughly chewed. d. It is dangerous to cool drinking water by placing river ice in it. e. The use of paper towels aids in checking the spread of disease. f. Milk will not sour readily when placed in a cool place.

11. Write in the parenthesis at the right of each word or phrase in column B the number of the word or phrase in column A most closely related to it. (10)

Column A	*Column B*	
1. 30 inches at sea level	bending of tin	( )
2. moving body	phosphorus	( )
3. brings light rays to a focus	nitrogen	( )
4. siphon	light	( )
5. causes expansion	turns litmus red	( )
6. low kindling temperature	velocity of sound	( )
7. 186,000 miles per second	kinetic energy	( )
8. four-fifths of the air	carbon dioxide	( )
9. physical change	lens	( )
10. alkali	heat	( )
11. 1087 feet per second		
12. acid		
13. turns limewater milky		

12. Complete *each* statement by writing on the dotted line the word or group of words that makes the statement true. (10)

a. Nitric acid may be used to test for..............................

b. When hydrogen burns in air, ... is formed.

c. Heat or energy travels from the sun by ....

d. About June 21 the sun's rays strike the earth most directly at ....

e. Sound is produced by a .... body.

f. At sea level the boiling point of water is .... degrees Fahrenheit.

g. The height of the mercury in a barometer at sea level is about .... inches.

h. Organic soil is called ....

i. Rusting is a form of ....

j. A Calorie is a unit for measuring ....

13. On the line after *each* statement write the name of the process indicated. (10)

a The process by which immunity to smallpox is acquired. ....

b. Substituting a poor grade of food for a more expensive one. ....

c. Action of yeast on sugar. ....
d. Changing nitrogen of the air into nitrogen compounds. ....
e. The process whereby insoluble foods are changed into soluble substances. ....
f. Heating milk to 145° F. for about half an hour and then rapidly cooling the milk. ....
g. The process by which the human body uses oxygen in the body cells. ....
h. The passage of digested food through the villi of the small intestine into the blood. ....
i. The elimination of carbon dioxide, water and nitrogenous wastes from the body. ....
j. The burning of sulphur in a room after a contagious disease. ....

14. After *each* illustration below write the letter (A, B, C, D, E) of the statement of fact that corresponds to it. (10)

Statements of Fact: A. The atmosphere exerts pressure. B. Light travels faster than sound. C. Heat, water and carbon dioxide are given off as a result of oxidation. D. Some diseases are prevented by foods that contain vitamins. E. Plants absorb water by osmosis.

Illustrations: We see lightning before we hear the thunder. Moisture collects on a cold glass plate held over a burning candle. A medicine dropper is used to pick up a liquid. Sprinkling salt on the soil is often used to kill weeds. The steam from a distant factory whistle can be seen before the whistle is heard. Scurvy is caused by lack of fresh vegetables. The diet of a child should contain orange juice. Mammals are warm-blooded. A vacuum cleaner is used to pick up dirt. A balloon rises.

15. A green plant in the sunlight making sugar from inorganic raw materials may be likened to a factory. Describe this factory by writing the correct names in the spaces provided. (10)

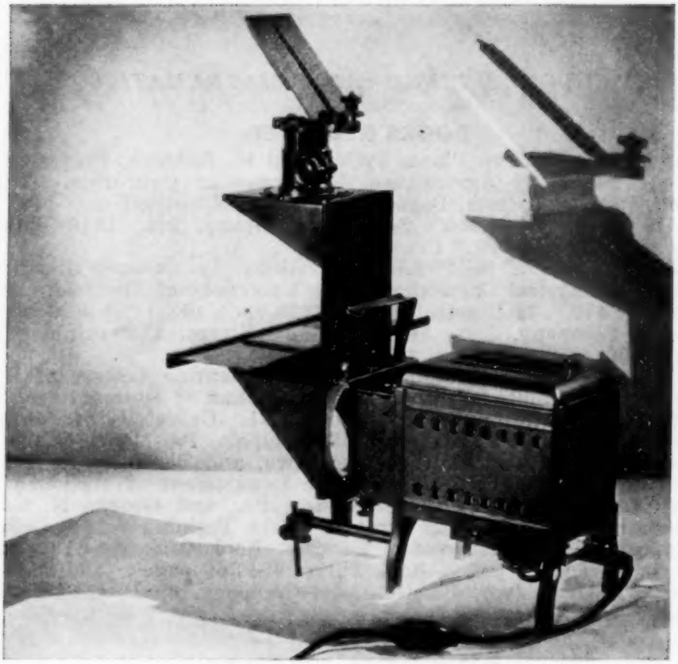
a. Raw material used from the air. .... *b.* Raw material used from the soil. .... *c.* The process by which the material from the soil is taken into the plant. .... *d.* The process by which the raw materials are made into sugar. .... *e.* A by-product of the process. .... *f.* The coloring matter that is essential to the process. .... *g.* The source of the energy that is used in the process. .... *h.* The name of a plant that can not manufacture sugar. .... *i.* An organism that depends on plants for its existence. .... *j.* The fuel element in sugar.

COMMUNICATIONS RECEIVED.

1. *G. Ginat, professor de physique, au Lyceé de garcon, Le Havre, France.* French examinations in Physics, Chemistry and Mathematics.
2. Test used by a large steel corporation. (To be published in an early number of SCHOOL SCIENCE AND MATHEMATICS.)
3. Unit Tests in Physics by David W. Evans, West High School, Cleveland, and David P. Harry, Jr., Graduate School, Western Reserve University.

What would you like to have published?

The kind of phonograph recording used by Edison in his original work promises to return to practical use and produce the most faithful reproductions of music. Halsey A. Frederick of the Bell Telephone Laboratories demonstrated to the Society of Motion Picture Engineers and the Institute of Radio Engineers new disc records cut by the vertical method instead of the lateral method used in ordinary phonographs. The new system of music reproduction is claimed to eliminate needle scratch.



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BOOKS RECEIVED.

The Botany of Crop Plants by Wilfred W. Robbins, Professor of Botany, College of Agriculture, University of California. Third Edition, Revised. Cloth. Pages x+639. 269 Illustrations. 14x21.5 cm. 1931. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $4.00.

Recent Advances in Physical Chemistry by Samuel Glasstone, Lecturer in Physical Chemistry at the University of Sheffield. Cloth. Pages vii+470. 32 Illustrations. 13x20 cm. 1931. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $3.50.

The Ingenious Dr. Franklin, Selected Scientific Letters of Benjamin Franklin Edited by Nathan G. Goodman of Germantown, Pa. Board. Pages xi+244. 15x20.5 cm. 1931. University of Pennsylvania Press, 3438 Walnut Street, Philadelphia, Pa. Price $3.00.

Arithmetic for Today, Book One, Two, and Three by Robert F. Anderson, Professor and Head of the Department of Mathematics, State Teachers College, West Chester, Pa., and George N. Cade, Professor of Education and Director of the Training School College of Education, University of Arkansas. Book One, vi+313 pages, Book Two, vi+314 pages, Book Three, vi+346 pages. Cloth. 13.5x 19 cm. 1931. Silver, Burdette and Company, 39 Division Street, Newark, New Jersey. Price each 72 cents.

PAMPHLETS RECEIVED.

Lists of Essential Apparatus for Use in High-School Sciences by T. C. Holy, Research Associate, and D. H. Sutton, Research Assistant, Bureau of Educational Research, Ohio State University. Pages vii+32. 16x24 cm. 1931. Price 75 cents. Ohio State University, Columbus, Ohio.

The Iowa Algebra Aptitude Test by Harry A. Greene, Associate Professor of Education, University of Iowa, and Alva H. Piper, Superintendent of Schools, Ayrshire, Iowa. Form A. 6 pages. 21.5x28 cm. 1931. Class Record, Answer Key and Examiner's Manual for same. Published by Bureau of Educational Research and Service, Extension Division, University of Iowa, Iowa City.

Instructional Tests in Plane Geometry, Comprising 36 tests covering the various phases of the subject by Florence Bishop, Chairman, Mathematics Department, Central High School, Flint, Michigan, and Manley E. Irwin, Assistant Director, Curriculum Research, Public Schools, Detroit, Michigan. 72 pages. 16x25.5 cm. 1932. List price 36 cents and Key for teachers 16 cents. World Book Company, Yonkers-on-Hudson, New York.

Educating all the Children of all the People by Francis W. Kirkham, Educational Director, National Child Welfare Association. Pages ix+57. 15x23.5 cm. Bulletin No. 11. 1931. United States Government Printing Office, Washington, D. C. Price 10 cents.

Bibliography of Research Studies in Education, 1929-1930. Prepared in the Library Division Office of Education by Edith A. Wright. Pages xii+475. 14.5x23 cm. Bulletin, 1931, No. 13. United States Government Printing Office, Washington, D. C. Price 85 cents.

BOOK REVIEWS.

Ourselves and the World, The Making of an American Citizen, by Frederick E. Lumley, Professor of Sociology, the Ohio State University, and Boyd H. Bode, Professor of Principles of Education, the Ohio State University Illustrated by Guy Brown Wiser. First Edition. Cloth. Pages viii to 591. 13.5x20.5 cm. 1931. McGraw Hill Book Company, 370 Seventh Avenue, New York. Price $3.00.

"The central idea of this book is the idea of democracy as a guid-

ing principle for intelligent living. The conception of democracy which it presents reaches far beyond the notion of democracy as a political structure and makes it a living process, a way of human growth." Thus in the Preface of their book the authors not only profess their faith in a political democracy which has been more vigorously attacked in recent years than ever before; but they also enlarge the concept to include all the social machinery for "the attainment of a rich and abundant life."

"In developing this idea of democracy," the authors further state, "the attempt is made to sketch the main outlines of how every reader—and the author and publishers too—began life on the human level, how he came to be what he is now, and what he may reasonably be expected to be and do as a citizen. Accordingly, the book contains such representative chapters as those on "Heredity and Environment," "Becoming Human," "Changing Institutions," "The Ideal of Democracy," "The Family," "The School," and "Popular Government."

The simple, lucid, conversational style of this book—a style which, it must be said, is occasionally somewhat lacking in dignity—should win and hold the interest of the student. Moreover, the clever pen-and-ink illustrations will doubtless mitigate for him the length of the volume, which to the casual reader seems like a combination of "Why We Behave Like Human Beings," an elementary sociology textbook and a high school civics. It is, to be sure, considerably more than that, chiefly by virtue of its great unifying concept, democracy.

"Ourselves and the World" would, of course, be an excellent addition to any public or school library. Perhaps its inclusion of material from a number of senior high school and junior college subjects renders it unsuitable as a textbook for any one of them except elementary sociology and "orientation" courses. For the latter especially it should be excellent. And when it is more fully realized that the schools should teach how to make a life as well as a living, this book may afford a platform of social ideals upon which all races and creeds may unite. John L. Auble.

The Romance of Transport by Ellison Hawks, Fellow of the Royal Astronomical Society and Editor of The Meccano Magazine. Numerous Illustrations. Cloth. 333 pages. 14.5x21 cm. 1931. Thomas Y. Crowell Company, New York, N. Y. Price $3.00.

The boys and girls in school today cannot form a mental picture of a country without automobiles, airplanes, and fast trains and ocean liners. They have no idea of the condition of the country just a generation ago when a trip to the state capital was a bigger event than a voyage to a foreign land today. This very interesting book by Mr. Hawks gives a vivid description of conditions of travel and transport from the tribal runner to the airplane. His description is illuminated by interesting anecdotes of accidents or conditions of transport written at the time described. Every important country and time are included in the story. Every type of conveyance and every means of transportation are described. The book is well illustrated with drawings and half-tone pictures. It is entertaining and educational. G. W. W.

Essentials of Biology, by W. H. D. Meier, State Normal School, Framingham, Mass., and Lois Meyer, State Teachers' College, Trenton, New Jersey. vii+529 pp., 332 figures. Ginn and Company. 1931.

This biology text is well balanced in the treatment of animal and plant life. It covers so much ground, however, that it would be impossible for any high school class to complete satisfactorily all of the work in a year. The mass of material offered permits a selection to suit local conditions, which is an advantage.

With a few exceptions, each chapter begins with a significant quotation from some prominent author and ends with a vocabulary, questions for study and discussion, and a list of problems. Tables of references are given where they seem necessary. One of the valuable features of the book is a glossary of fundamental terms giving a key to pronunciation.

One section of the book is designated as economic biology. As a matter of fact, economic aspects are treated in connection with the work throughout. Jerome Isenbarger.

Biology Notebook, by W. H. D. Meier, State Teachers' College, Framingham, Massachusetts, and Dorothy Meier, Hunter College, New York City. viii+160 pp. Ginn and Company.

This notebook was prepared to be used with Essentials of Biology by Meier and Meier. It could be used with any other similar text. It is loose leaf in form which permits the exercises to be used in any order.

Questions, suggestions, or directions for procedure are given, then space is left for answer, discussion or drawing. It does not call for the filling of blanks with the single word type of answer. It permits the use of complete sentences and extended discussions. It does avoid much useless writing with a saving of time. The work is more easily checked and graded than with the essay type of report. Text assignments are given along with each exercise. The references are all to the Essentials of Biology. Jerome Isenbarger.

Principles and Practice of Hygiene, by John R. Cain, M. D. Assistant Professor of Hygiene for Men, University of Illinois xiv+251 pp., 58 illustrations. P. Blakiston's Son and Co., 1012 Walnut St., Philadelphia.

The book is made up of two divisions, Part I dealing with the principles of the organic phases of hygiene, and Part II the infections and their prevention. There are also chapters on poisons and physical injuries.

The appendix contains food tables, and tables of references and readings. Scattered through the book are lists of thought questions and questions on the context. These are usually accompanied by problems which are suitable for assignment to college students for outside preparation. As the title indicates, the book is a treatment of principles as well as practice of hygiene. The method of attack puts the subject on the same basis as the other sciences. It recognizes the scientific background.

The materials and approach show evidences all through of having been developed through real class work. For this reason it can be depended upon as an excellent text and guide in the hands of students taking the course in hygiene in college classes.

Jerome Isenbarger.

A Shorter Course in Organic Chemistry. J. C. Colbert, Assistant Professor of Chemistry in the State University of Oklahoma. First Edition. Century Chemistry Series, James Kendall, Editor. The Century Company, New York City, 1931. xviii+352 pp. 15x23 cm. $3.60.

A well organized elementary text suited to the needs of the average beginner. The author, a teacher of considerable experience has developed the subject matter with just such a student in mind. Large and clear structural formulas are used in practically all of the equations. Numerous charts show in a schematic way the relationships between the members of a given group and are used to summarize the type reaction of each group. More charts show the industrial products and uses. At the end of both the aliphatic and aromatic series a large fold in chart sums up the relations in the series.

A table of physical properties is appropriately placed for each

class of compounds. Problems, review questions and summaries are frequent. A large detailed outline with suitable review questions is placed at the end of the aliphatic series.

The continuity is well developed and relationships are stressed. Some idea of the current interpretation of reactions on the basis of electronic shift and transfer is included.

Completion of reactions is not stressed and too little consideration is given to equilibrium relations. The arbitrary idea that reactions go this way or that way for no apparent reason should not be allowed to develop even in a beginner.

264 pages are devoted to the aliphatic series and only 69 pages to the aromatic series.

The book is a very good text, informal in style, written for the student and safeguarding him as much as possible against a poor teacher—a decided contribution to good teaching.

James B. Parsons.

Directed Study Work Book for General Science, by Russell E. Bridges, Assistant Principal, Highlands High School, Fort Thomas, Kentucky and William C. Lee, Head of Department of Physical Science, Kentucky Wesleyan College, Winchester, Kentucky. Paper. 21.5x28 cm. 1930. Rand McNally and Company, Chicago. Part one, tests 1 to 11 with tests for each and one general test. Part two, tests 12 to 18 with tests for each and one general test.

The workbooks, parts I and II contain a very complete and well selected bibliography. Definite study suggestions are given to the teacher and the pupils. The workbook contains eighteen units. Each unit contains a forecast and a list of topics for report. The units are developed through a series of problems. Each problem contains a list of references; words for study and use; guide questions, and related problems built up on A and B contract basis. Additional space is given for study notes with each unit.

Tests are provided for each unit in an easily detached form. The tests are objective and consist of the forms generally used.

I. C. D.

Learning and Test Activities in General Science, A Work Book with Unit Tests by Ralph K. Watkins, Professor of Education, University of Missouri and Ralph C Bedell, Teacher of General Science, Southwest High School, Kansas City, Missouri. Paper. 13 Units. 184 pages. 20.5x28 cm. 1931. The Macmillan Company, 2459 Prairie Avenue, Chicago, Ill. Price 60 cents.

The material in this workbook is divided into thirteen units. Each unit has a pre-test and a final test. Each unit is divided into problems. Each problem has many completion sentence type of statements to complete. With each unit is also listed additional things to do, suggested reading and a summary of facts and principles.

The references are made largely to the textbooks in the special sciences in the high school. I doubt if it is a good plan to attempt to teach general science from the textbooks in biology, chemistry and physics.

I. C. D.

Science Education in the Secondary Schools of Sweden by Holger Frederick Kilander, Professor of Biology and Hygiene, Upsala College, East Orange, New Jersey. Cloth. Pages vi+166. 14.5x23 cm. 1931. Bureau of Publications, Teachers College, Columbia, University, New York City. Price $1.75.

For some time science instruction and science courses have been on trial before the educational court. As teachers of science we may not realize that we are now in the midst of what may turn out to be a revolutionary reorganization of our science curriculum. It is important that we attempt to learn both our virtues and our faults. In

this book Dr. Kilander presents one method of making such a study. He has made an unusually thorough study of science education in another country and has compared the educational practices in science found there with those which obtain in our own country. He has studied aims, methods of instruction, courses of study, teacher preparation, correlation of science subjects, relation of science to other subjects and to the needs of citizens. In all these topics he has collected and presented definite data, examined them critically and pointed out their advantages or weaknesses as compared with American practices.

Some of his findings are very interesting: The chief aim of the study of science is acquiring information; the textbooks are brief, often little more than outlines of the subject; individual laboratory work is limited; instruction is by demonstration and oral questioning; examinations are rare, usually only the final examination given at graduation from one school to another; science courses are interdependent and extend through almost the entire school time after fourth school year; teachers are well prepared in subject matter but are not required to have much professional training.

Anyone who has made a study of European education will not be startled at these findings, but his thinking machinery will be set in motion by the comparisons made. The author's real contribution is his critical analysis. His criticism is straight forward and impartial. The book is a real help in analyzing our own deficiencies and is especially recommended to science teachers who have not studied European school systems. G. W. W.

Workbook for Use With the Science of Everyday Life by Edgar F. Van Buskirk and Edith Lillian Smith, assisted by James R. Wilson. Paper. 214 pages. 20x28 cm. 1931. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price 72 cents.

This workbook contains detailed instructions to the teacher and the pupils on how to use the workbook. The material is divided into five main divisions and twenty-one subdivisions. Each unit contains the laboratory work and general classroom work for the different problems. Many diagrams and tables are used. Each problem has a summary test. There is also a summary for each unit. A set of objective tests for each unit accompanies the workbook.

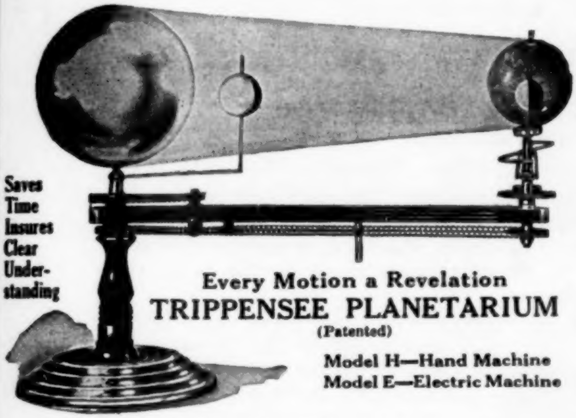
I. C. D.

EIGHTH ANNUAL JUNIOR HIGH SCHOOL CONFERENCE.

The Eighth Annual Junior-High-School Conference will be held at New York University on March 18-19, 1932. The central theme of this conference will be: "Improving Junior-High-School Instruction." Two general sessions coming Friday evening and Saturday morning will be followed by some thirty Round Tables related to the central topic.

This conference is unique in that it is a cooperative arrangement, the directive force being vested in an Advisory Committee of thirty-six representative educators distributed throughout the eastern states. The committee just referred to gives practical direction to the character of the conference. New York University offers the facilities for making this clearing house treatment of junior high school problems possible.

The regional character of the conference makes it one of the most important of its kind in the country. In 1931, upwards of 2,000 attended it. The following states took an active part in the conference as revealed by talent and individual attendance: New York, Pennsylvania, New Jersey, Connecticut, Delaware, Maryland, Rhode Island, Massachusetts, and Ohio.



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A PROJECTION GALVANOMETER.

By Paul Rood,
Western State Teachers College, Kalamazoo, Michigan.

The problem when demonstrations involving small electric currents, such as those used in showing Faraday's principle of induction are to be made, is to procure a galvanometer which has a pointer and scale large enough to be seen by everyone and which at the same time has the requisite sensitivity.

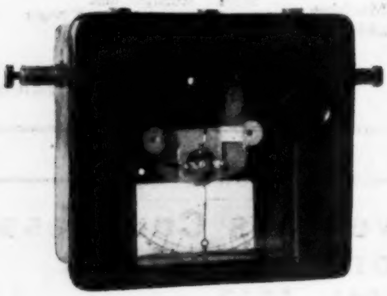

Fig. 1.

For such demonstrations a galvanometer movement, mounted as shown in Figure 1, makes an inexpensive and very satisfactory instrument. The movement used was a Jewell, Pattern No. 51, fitted with a double pointer.* It was mounted in a discarded voltmeter case, such as the Jewell Company uses for its Pattern No. 43 voltmeter, with openings cut in its front and back large enough to assure visibility of the lower part of the double pointer. A glass scale, made on a lantern slide from one of the standard galvanometer scales, was glued in place at the rear of the pointer. The unit is placed at the focus of a projection lantern and the pointer and the scale projected on the screen.

The sensitivity of the instrument is such that by putting a little iron in the center of a 125-turn helix of No. 18 copper wire and rotating it a quarter of a turn in the proper plane, the effect of cutting the lines of force of the earth's field may be shown.

The experiments using this galvanometer are made at the demonstration desk and small permanent leads go from it around the room to the galvanometer.

INDIANS TO EAT BUFFALO, THE MEAT THEIR FATHERS KNEW.

Blackfoot Indians will eat buffalo meat this winter. The "strong food" on which their warlike ancestors fed has been denied Indians as well as white men ever since the near-extermination of the bison at the end of the "Wild West" days. Now, however, the government-protected herds in Yellowstone National Park and elsewhere are more numerous than their natural range warrants, and surplus animals have to be disposed of every year. This year the Blackfoot on the reservation near here are facing a lean winter because grasshoppers and drought took too heavy a toll on their lands last summer. So Supt. Aven Scoyen of Glacier National Park has arranged to have 100 old bison supplied to the Indians, to be killed for meat.—*Science Service.*

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*The company manufacturing the galvanometer movement furnished the double pointer.